MERRIMACK RIVER BASIN

NEW IPSWICH, NEW HAMPSHIRE

SOUHEGAN RIVER WATERSHED DAM NO. 14

NH 00433

NHWRB 175.01

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS. 02154

AUGUST 1979

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MS, INSPECTION, DAM SAFETY,

rrimack River Basin
w Ipswich New Hampshire
rnace Brook Tributary of Souhegan River

STRACT (Continue on reverse side if necessary and identify by block number)

e dam is an earth embankment 1500 ft. long and 35 ft. high. It is small in ze with a high hazard potential. The tst flood is the PMF. The dam is in od condtition at the present time although there are some remedial measure ich must be undertaken by the owner. No conditions were observed which require ditional investigation.

SOUHEGAN RIVER WATERSHED DAM NO. 14
NH 00433

MERRIMACK RIVER BASIN
HILLSBOROUGH COUNTY, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.:	NH 00433
NHWRB No.:	175.01
Name of Dam:	SOUHEGAN RIVER WATERSHED DAM NO. 14
Town:	New Ipswich
County and State:	Hillsborough County, New Hampshire
Stream:	Furnace Brook, Tributary of Souhegan River
Date of Inspection:	April 30, 1979

BRIEF ASSESSMENT

The Souhegan River Watershed Dam No. 14 is located on Furnace Brook approximately 1/2 mile upstream of New Ipswich Center, New Hampshire. The dam is an earth embankment 1,500 feet long and 35 feet high with a drop inlet service spillway structure and a 30 inch outlet conduit. An earth emergency spillway 120 feet wide is cut into the left abutment.

The dam is owned by the New Hampshire Water Resources Board. It was designed by the Soil Conservation Service for the purpose of flood protection in the Souhegan River Watershed.

The drainage area of the dam covers 2.3 square miles of steeply sloping woodland with some pasture and development. The dam normally impounds only 23.4 acre-feet but has a maximum impoundment of 885 acre-feet. The dam is SMALL in size and its hazard classification is HIGH, since significant property damage and loss of life could result in the event of a dam failure.

The test flood for this dam is the Probable Maximum Flood. The peak inflow for this flood is 6,732 cfs. Because of storage, the resulting peak discharge is 4,210 cfs compared to a spillway capacity of 4,350 cfs. The water surface would be at elevation 1076.3 feet (MSL) or 0.2 feet below the top of the dam.

The dam is in GOOD condition at the present time. Remedial measures to be undertaken by the owner include filling in animal burrows, mowing of slopes, removing shrubs or saplings, and filling holes left by their roots, backfilling tire ruts, including annual operation of drain gate in the inspection procedure, and developing a formal written emergency flood warning system for the dam.

No conditions were observed which require additional investigation. The remedial measures outlined above should be implemented within two years of receipt of this report by the owner, however, the program of annual technical inspections should be continued.

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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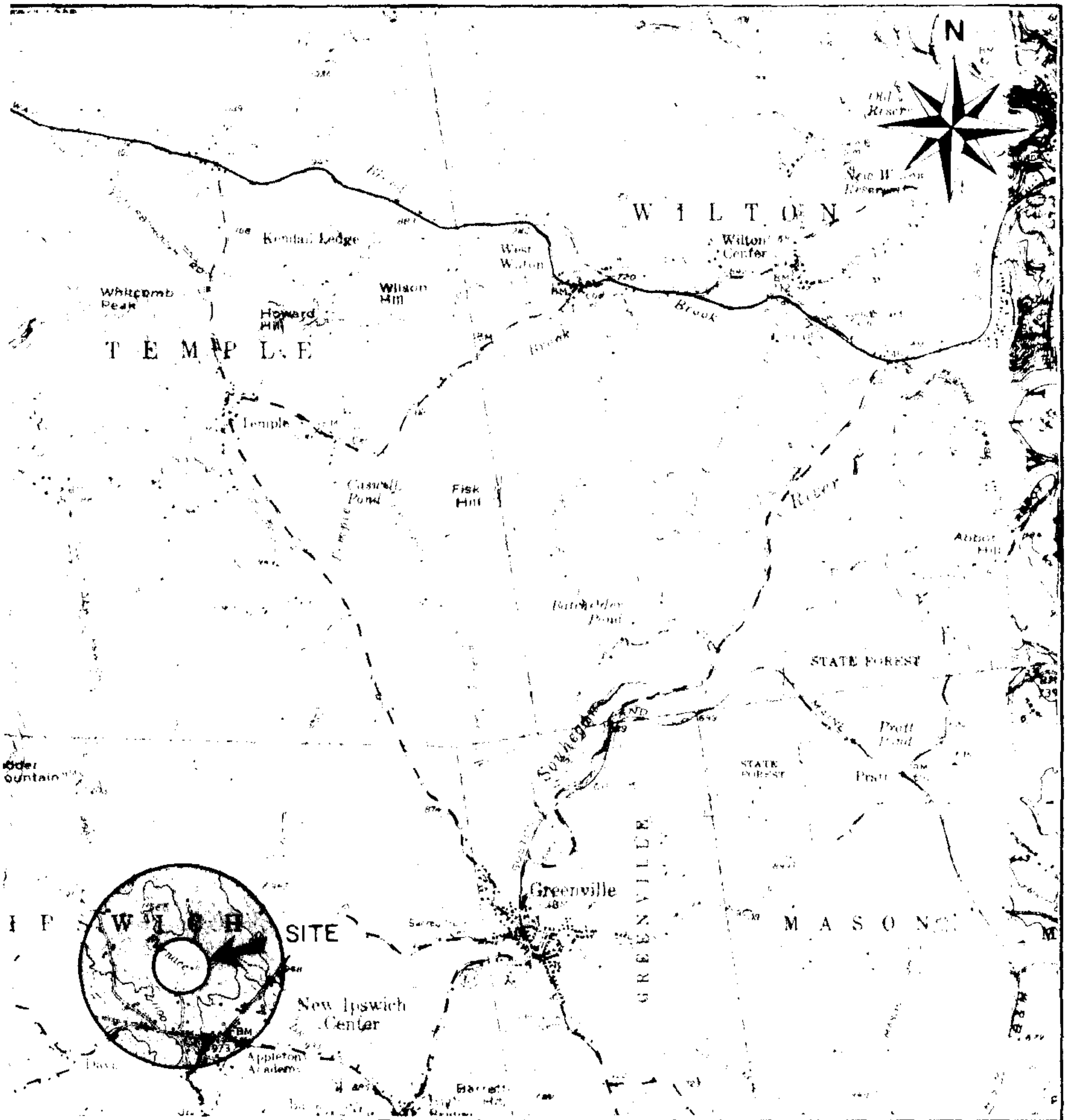
Overview from left abutment



- SCALE -

0 1/2 1 2 (MILES)

FROM: USGS PETERBOROUGH & MILFORD-N.H. QUADRANGLE MAPS.

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

SOUHGEN RIVER WATERSHED
DAM No. 14 NEW HAMPSHIRE

FILE No. 2327

			SCALE AS NOTED
			DATE MAY 1979

PHASE I INSPECTION REPORT

SOUHEGAN RIVER WATERSHED DAM NO. 14

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to GZD under a letter of March 30, 1979 from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-79-C-0058 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams, and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The Souhegan River Watershed Dam No. 14 is located on Furnace Brook approximately one-half mile upstream of New Ipswich Center. It can be reached from an access road off Ashley Mill Road, which intersects state Routes 123 and 124 in New Ipswich. The dam is shown on USGS Peterborough, N.H. quadrangle at approximately coordinates N 42° 45.9', W 71° 51.6' (see location map on page v). Figure 1 of Appendix B is a site plan for this dam.

(b) Description of Dam and Appurtenances

The dam consists of an earth embankment with an earthfill cutoff trench below the embankment, a principal spillway with a reinforced concrete riser and outlet pipe, and an emergency spillway located at the left abutment. The total length of the dam is 1620 feet, of which 120 feet is the emergency spillway.

(1) Embankment (See pgs. B-3, B-4, B-5, and B-6)

The embankment is made up primarily of silty sand (SP-SM). It is 1500 feet long with a 53 degree bend approximately 700 feet from the right abutment. It is a maximum of 35 feet high. The upstream and downstream slopes are 2.5 horizontal to 1 vertical and the width of the crest is 15 feet.

Beneath the embankment is an earthfill cutoff trench which is 12 feet wide at the bottom. According to available plans, it is constructed of the same material as the embankment. The cutoff trench was designed and constructed to extend through sand and gravel layers to underlying, less permeable soil.

The dam is founded on schist at the left end and dense glacial till at the right end.

(2) Principal Spillway (See pgs. B-6 and B-7)

The principal spillway consists of a reinforced concrete drop inlet structure with a sluice gate controlled inlet pipe and two uncontrolled orifice inlets, and an outlet pipe supported on a concrete cradle.

The riser structure is 20 feet high and 8.5 feet wide normal to the axis of the dam. It is 4.5 feet long parallel to the embankment and flares to 13.5 feet long at the top. The walls of the structure are 12 inches thick and the top slab is 8 inches thick.

At the base of the structure is a 15 inch diameter, vertical lift, sluice gate inlet which is controlled by a wheel operated bench stand with a rising stem. A 15 inch diameter, asphalt coated, corrugated metal pipe extends 24 feet upstream from the gate into the impoundment pool. Plans indicate the upstream end of this pipe is protected by a trash rack.

The "low stage inlet" is a single uncontrolled opening approximately 10 feet above the sluice gate. It is 2 feet 5 inches wide and 12 inches high and is located in the right side of the riser. It is protected by a trash rack assembly 5 feet 3 inches high and 4 feet 3 inches wide. This assembly is fabricated from galvanized steel angles and reinforcing rods.

The "high stage inlet" consists of two openings approximately 16 feet above the sluice gate. They are 7.5 feet wide and one foot 2 inches high and are located in the left and right sides of the flared portion of the riser structure. They are protected by four galvanized steel pipes, 2.5 inches in diameter, placed horizontally in front of each opening.

The riser structure is drained by a 30 inch diameter reinforced concrete pressure pipe. It is approximately 152 feet long and drops approximately 2 feet over that length. The pipe penetrates the downstream side of the riser structure and the earth embankment. It is supported by an 8 inch thick concrete cradle within the embankment. Plans indicate three concrete anti-seep collars cast around the pipe within the embankment.

The end of the cradle extends downstream of the embankment and its end is supported on a reinforced concrete "tee" bent. The top flange of the tee bent is 12 inches thick, 18 inches deep, and 4.5 feet wide. The stem is 12 inches by 18 inches and is supported on a 3 foot square footing. The outlet conduit discharges into a stone revetted plunge pool.

(3) Emergency Spillway (See pgs. B-3 and B-4)

The grass covered emergency spillway was excavated in earth in the left abutment. It curves to the right around the embankment and is 120 feet wide at the control section. It is approximately 700 feet long and lies approximately 6 feet below the top of the embankment. The side slopes are 2 horizontal to 1 vertical.

(4) Foundation and Embankment Drainage (See pg. B-5)

A blanket drain of clean sand underlies the downstream toe of the embankment over its full length. In conjunction with this is a trench drain from station 7 + 00 (left abutment) to station 12 + 60 and a trench drain with an 8 inch perforated pipe from station 12 + 60 to station 21 + 00 (right abutment). The pipe and trench drains (toe drains) outlet at station 14 + 75 on either side of the principal spillway outlet pipe.

(c) Size Classification

The dam's maximum capacity of 885 acre-feet and height of 35 feet place the dam in the SMALL size category according to the Corps of Engineers Recommended Guidelines.

(d) Hazard Potential Classification

The hazard potential classification for this dam is HIGH because of the significant economic losses and potential for loss of life downstream in the event of dam failure. Section 5 of this report presents a more detailed discussion of the hazard potential.

(e) Ownership

The dam is owned by the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301. They can be reached by telephone at 603-271-3406.

(f) Operator

The operation of the dam is controlled by the New Hampshire Water Resources Board. Key officials are as follows:

George McGee, Chairman
Vernon Knowlton, Chief Engineer
Donald Rapoza, Assistant Chief Engineer

The Board's telephone number is 603-271-3406. Alternatively, the Board can be reached through the state capital at 603-271-1110.

(g) Purpose of the Dam

The purpose of the dam is to reduce downstream flooding by providing temporary storage for the runoff from 1485 acres of watershed. This temporary storage is released gradually through the low and high stage outlets of the principal spillway.

(h) Design and Construction History

A small dam was originally built at this site prior to 1836. It was removed during the construction of the present dam between 1962 and 1964. The present dam was designed by the U.S. Department of Agriculture, Soil Conservation Service and was constructed as part of a series of floodwater retarding dams for the Souhegan River Watershed.

(i) Normal Operational Procedure

The dam is normally self regulating. The pond drain gate is operated only during infrequent maintenance checks.

1.3 Pertinent Data

(a) Drainage Area

The watershed for dam No. 14 covers 2.3 square miles consisting of steeply sloping woodland (approximately 80% of area) with some pasture and development. The normal pool elevation is 1060.0 feet above mean sea level.

(b) Discharge at Damsite

1) Outlet Works

Normal discharge at the site is through the 30 inch diameter outlet pipe. In the event of severe flooding, water would flow over the emergency spillway at elevation 1070.5 feet (MSL). The invert of the low stage orifice is at elevation 1060.0 feet (MSL). The invert of the high stage orifice is at 1067 feet (MSL).

2) Maximum Known Flood

There is no available data for the maximum known flood at the damsite.

3) Ungated Spillway Capacity at Top of Dam

The capacity of the principal spillway with the reservoir at top of dam elevation (1076.5 feet MSL) is 282 cfs. The capacity of the emergency spillway at this level is 4068 cfs.

4) Ungated Spillway Capacity at Test Flood

The capacity of the principal spillway with the reservoir at test flood elevation (1076.3 feet MSL) is 280 cfs. The capacity of the emergency spillway at this level is 3930 cfs.

5) Gated Spillway Capacity at Normal Pool

There are no gated spillways. The only gate is on the pond drain inlet. This gate is normally closed but operation of this gate would not change the capacity of the principal spillway.

6) Gated Spillway Capacity at Test Flood

As previously stated, there are no gated spillways.

7) Total Spillway Capacity at Test Flood

The total spillway capacity at the test flood elevation (1076.3 feet MSL) is 4210 cfs.

8) Project Spillway Capacity at Test Flood

The peak project discharge during the test flood is 4210 cfs.

(c) Elevation (feet above MSL)

(1) Streambed at centerline of dam: 1048.0

(2) Maximum Tailwater: Unknown

(3) Upstream Portal Invert Diversion Tunnel: Not applicable

(4) Normal Pool: 1060.0

(5) Full Flood Control Pool: 1070.5

(6) Spillway crest

a) Pond drain inlet: 1050.5

b) Low stage inlet: 1060.0

c) High stage inlet: 1067.0

d) Emergency spillway: 1070.5

(7) Design surcharge: 1074.5

(8) Top of dam: 1076.5

(9) Test flood design surcharge; 1076.3

(d) <u>Reservoir</u>

(1) Length of design highwater pool: 3200 ft.

(2) Length of normal pool: 1000 ft.

(3) Length of flood control pool: 2800 ft.

(e) <u>Storage</u> (Acre-Feet)

(1) Normal pool: 23.4

(2) Flood control pool: 413

(3) Spillway crest pool

a) Low stage inlet: 23.4

b) High stage inlet: 186 ±

c) Emergency spillway: 413

(4) Top of dam: 885

(5) Test flood pool: 868 ±

(f) <u>Reservoir Surface</u> (Acres)

(1) Normal pool: 9.5

(2) Flood control pool: 65

(3) Spillway crest pool

a) Low stage inlet: 9.5

b) High stage inlet: 50 ±

c) Emergency spillway: 65

(4) Test flood pool: 93

(5) Top of dam: 95

(g) <u>Dam</u>

(1) Type: earth embankment

(2) Length: 1500 ft.

(3) Height: 35 ft.

(4) Top width: 15 ft.

(5) Side slopes: upstream and downstream: 2.5:1

(6) Zoning: homogeneous, semi-pervious silty sand

(7) Impervious core: none

(8) Cutoff: 12 ft. wide, earthfill

(9) Grout curtain: none

(h) <u>Diversion and Regulating Tunnel</u>

Not applicable

(i) <u>Spillways</u>

(1) Type

a) Principal spillway: reinforced concrete drop inlet

b) Emergency spillway: grass covered earth channel cut in left abutment

(2) Length of weir

a) Pond drain inlet: 15 inch diameter pipe

b) Low stage inlet: 2 ft. 5 inches

c) High stage inlet: 15 feet

d) Emergency spillway: 120 feet

(3) Crest elevation (feet above MSL)

a) Pond drain inlet: 1050.5

b) Low stage inlet: 1060.0

c) High stage inlet: 1067.0

d) Emergency spillway: 1070.5

(4) Gates: 15 inch diameter sluice gate on pond drain inlet

(5) Upstream channel: reservoir

(6) Downstream channel: narrow with small trees and shrubs

(d) Regulating Outlets

The only regulating outlet is a 15 inch diameter pipe controlled by a wheel operated sluice gate. The pipe invert is at elevation 1050.5 feet above MSL. The purpose of this outlet is for pond drainage and it is not normally used.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

Among other data available from the Soil Conservation Service are hydrologic and hydraulic computations, structural computations, a geological report, soil laboratory test results, and design plans.

2.2 Construction Data

"As Built" plans are available for this dam and show good agreement with design plans and visual inspection.

2.3 Operational Data

No operational data is available as the dam is self operating.

2.4 Evaluation of Data

(a) Availability

Sufficient data is available to permit an evaluation of the dam when combined with findings of the visual inspection.

(b) Adequacy

There is sufficient design and construction data to permit an assessment of dam safety when combined with the visual inspection, past performance, and sound engineering judgment.

(c) Validity

Since the observations of the inspection team generally confirm the available data, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

The Souhegan River Watershed Dam No. 14 is in GOOD condition at the present time.

(b) Dam

(1) Earth Embankment (See Overview photos)

Five to ten rodent holes were observed two to six inches in diameter. These were located primarily in the downstream slope. There are tire ruts eight to ten inches deep in the crest and right upstream slope and some small shrubs and saplings were observed on both up and downstream slopes.

The toe drains were functioning with the left toe drain discharging approximately five gallons per minute and the right toe drain discharging approximately ten to twenty gallons per minute.

There is ponded water downstream of the right downstream slope but it appears to be runoff from natural slopes. There is no evidence of seepage.

(2) Emergency Spillway (See photo #1)

The emergency spillway is in GOOD condition. There are wet spots over much of the spillway but these are due to natural groundwater or ponded run-off. There is some minor growth of saplings and shrubs in the control section.

(c) Appurtenant Structures

(1) Drop Inlet Service Spillway Structure (See photos #5 and 6)

This structure is in good condition with no evidence of spalling, cracking, or efflorescence. Inspection of the interior of the structure from the manhole opening did not reveal any deficiencies. The sluice gate was submerged.

The sluice gate bench stand is in good condition. The hand wheel which operates the gate has been removed from the site to preclude unauthorized use.

The galvanized trash racks for both inlets are in good condition but clogged with debris.

Photographs of this structure are contained in Appendix C.

(2) Pond Drain Inlet Pipe

At the time of inspection the fifteen inch pond drain inlet pipe was completely submerged.

(3) Outlet Conduit (See photo #3)

The downstream end of this conduit is in good condition with no evidence of settlement, spalling, cracks, or efflorescence. The source of the present discharge is the low stage orifice opening.

The underside of the tee bent has spalled over the entire length of its downstream end in a 3 inch by 3 inch triangular pattern. The cause of this spalling is unknown. A similar condition exists at the bottom corner of the cantilevered end of the pipe cradle, but to a lesser extent.

3.2 Evaluation

The dam is generally in good condition. The potential problems noted during the visual inspection are listed as follows:

a) Animal burrows in the embankment slopes.

b) Tire ruts in the crest and right upstream slope.

c) Shrubs and saplings growing on embankment slopes.

d) Debris clogging the trash racks.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

No written operational procedures exist for this dam. The dam is normally self regulating.

4.2 Maintenance of Dam

An annual inspection is made jointly by the New Hampshire Water Resources Board and the Soil Conservation Service. Recommendations resulting from this inspection are implemented by the NHWRB.

4.3 Maintenance of Operating Facilities

Operation of the sluice gate for the pond drain inlet is checked approximately once every four or five years by NHWRB.

4.4 Description of Warning System in Effect

There is no warning system in effect.

4.5 Evaluation

The established operational procedures for this dam are generally satisfactory. Additional emphasis on routine maintenance will assist the owners in assuring the long-term safety of the dam.

SECTION 5 - HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

(a) General

Souhegan River Watershed Dam No. 14 is one of a series of floodwater retarding structures constructed by the Soil Conservation Service (SCS) on tributaries to the Souhegan River. This dam, completed in 1964, is located on Furnace Brook approximately 0.6 miles upstream of New Ipswich, New Hampshire. It is an earthfill structure with an orifice controlled principal spillway and a grass lined earth emergency spillway channel.

The Furnace Brook watershed is hilly and predominantly forested (approximately 80%) with small areas of pasture and developed land. The drainage area at the dam is 2.3 square miles.

A five-day drawdown period is required to bring the pool level down 6.7 feet from the emergency spillway crest. Ninety percent drawdown from the emergency spillway crest to the low stage orifice crest occurs after 6.3 days. The emergency spillway is designed to be used only in the event of a storm greater than the 100 year flood.

(b) Design Data

The elevation of the low stage inlet was determined by the 50 year sedimentation level of the watershed. The high stage inlet was set to allow storage of the four year, six hour storm without water passing over the high stage inlet. The emergency spillway crest was set to allow storage of the 100 year storm and the top of dam was determined based on the Probable Maximum Flood.

The data sources available for Souhegan Watershed Dam No. 14 include the original Soil Conservation Service (SCS) "Hydrology & Hydraulics" design calculations. These calculations dated 1962, establish storage-elevation and stage-discharge functions for the dam, develop inflow hydrographs, and route them through the reservoir.

The SCS design drawings of the dam and spillway structures along with related outlet and drainage facilities are available. These are dated 1963.

There are SCS "Maintenance Checklist" reports available for inspections of this dam dated May 19, 1977 and June 16, 1978.

(c) Experience Data

No records of flow or stage are known to be available for Souhegan Watershed Dam No. 14.

(d) Visual Observations

Souhegan River Watershed Dam No. 14 is an earthfill structure on Furnace Brook about 0.6 miles upstream of New Ipswich, New Hampshire. The earthen embankment rises 28.5 feet above the natural streambed to an elevation of 1076.5 feet above mean sea level (MSL) at the crest.

The emergency spillway is a grass lined earth channel which follows a semi-circular path around the left end of the dam. This channel was excavated out of the natural hillside, with the upper portion of the channel sideslope to the right formed by the dam embankment. It is 120 feet wide with side slopes 2 horizontal to 1 vertical and a bottom elevation at the control section of 1070.5 MSL, 6 feet below the dam crest. Following the centerline, the channel length is roughly 200 feet from the axis of the dam to the control section. Beyond the control section, the channel slopes down 0.03 feet per foot for another 300 feet, directing flows towards the natural stream channel downstream of the dam.

The principal spillway consists of a concrete riser structure. There is a 15 inch diameter pond drain with invert elevation 1050.5 which enters near the bottom of the riser. The pond drain is controlled by a sluice gate at the riser which is normally closed.

The spillway riser is drained by a 30 inch diameter concrete pipe which extends 152 feet downstream under the dam. The invert elevation at the riser is 1049.0 and at the outlet 1047.0.

A riprap lined stilling pool has been excavated at the outlet of the principal spillway. This pool is roughly 40 feet long with a bed 9 feet below the pipe invert, and leads to an excavated outlet channel with a bed at elevation 1042.0, 5 feet below the pipe invert. Sloping at 0.005 feet per foot, this man-made channel extends approximately 300 feet further downstream until it meets the natural Furnace Brook stream channel.

Shortly thereafter, roughly 500 feet downstream of the dam, Furnace Brook is crossed by a roadway embankment, about 7 feet high, with two 36 inch diameter concrete pipe culverts and one 24 inch diameter culvert.

Beyond this point the stream is narrow and well confined with a very steep gradient for a reach which extends approximately 0.4 miles downstream of the dam. Furnace Brook then takes on a milder gradient and flatter side slopes as it passes through New Ipswich center.

At New Ipswich, the stream runs adjacent to a playground before crossing a road with a 6 foot high embankment and two 36 inch diameter culverts. Downstream of this road and immediately adjacent to the stream on either side are two houses, with first floor levels approximately 6 feet and 8 feet above the streambed. Approximately 400 feet south of the stream, are three to five houses with first floor levels 10 to 15 feet above the streambed.

Furnace Brook then passes through a relatively flat open field which provides an extensive floodplain for another half mile. There is a commercial building in the floodplain here. Further downstream, the brook re-enters a wooded reach with steeper more confining side slopes continuing another mile before joining the Souhegan River as it skirts the edge of some low-lying open pasture land.

(e) Test Flood Analysis

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately-sized Test Flood. The original hydraulic and hydrologic design calculations provided by the SCS were used in this analysis.

Guidelines for establishing a recommended Test Flood based on the size and hazard classifications of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 1000 acre-feet and height of less than 40 feet classify this dam as a SMALL structure.

The hazard potential for the Souhegan Watershed Dam No. 14 is considered to fall within the HIGH category. This is based mainly on the possibility of some very damaging flooding at houses in New Ipswich 0.6 miles downstream should the dam fail. The rapid rate of rise to a high flood level, a rise of 7 feet near New Ipswich, makes loss of life a possibility as well.

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test Flood for a dam classified as SMALL in size with a HIGH hazard potential would be between one-half times the Probable Maximum Flood (PMF) and the PMF.

As the size of the dam is on the high side of SMALL, a Test Flood of the order of the PMF will be selected.

Using the Corps of Engineers New England Division's chart for "Maximum Probable Flood Peak Flow Rates, a PMF for this dam from its 2.3 square mile watershed is estimated to be 5,340 cfs. As part of the design calculations, the SCS developed a Freeboard Inflow Hydrograph with a peak flow rate of 6,732 cfs. This peak flow rate will be adopted as the Test Flood.

After accounting for the effect of storage in the flood control reservoir, the peak outflow through the spillway for this Test Flood was calculated by the SCS to be 4,210 cfs.

A stage-discharge curve was developed by defining discharge as the sum of flow through the principal spillway/outlet structure, and flow over the emergency spillway. The calculations determining these curves are documented in Appendix D.

Using this stage-discharge curve, the peak discharge of 4,210 cfs would result in a maximum stage of approximately 1076.3 feet MSL, 0.2 feet below the crest of the dam.

(f) Downstream Dam Failure Hazard Estimate

The peak outflow at the Souhegan Watershed Dam No. 14 that would result from dam failure is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." Failure is assumed to occur with the reservoir at design high water level, elevation 1074.5 feet MSL. This condition has been assumed instead of an overtopping condition with the reservoir at the level of the dam crest because it is considered more critical in terms of the consequences of dam failure.

That is, the normal spillway outflow with the pool at the top of the dam is so large that considerable damage would result at New Ipswich downstream prior to dam failure, so that the dam failure flood wave would cause only an increment of increased damage.

The design high water level is 2 feet below the dam crest and some 28.5 feet above the natural streambed. Assuming a 128 foot gap is opened in the dam, the peak failure outflow through this gap would be 35,100 cfs.

The assumed pre-failure spillway outflow would be sufficient to overtop the roadway embankment which crosses Furnace Brook approximately 500 feet downstream of the dam. After dam failure, this embankment would be seriously damaged if not completely destroyed and would impede the dam break flood wave only minimally.

Following essentially the "Rule of Thumb Guidelines" it is estimated that at the end of the first 0.4 mile reach of steep, well confined channel downstream of the dam the flood peak would be attenuated to 31,500 cfs. Using the same storage routing technique over the next 0.2 mile reach, the attenuated peak discharge at New Ipswich due to the dam break is estimated to be 28,000 cfs. This discharge would have a depth of flow estimated to exceed 14 feet, as compared to about 7 feet prior to dam failure, severely damaging the two houses adjacent to Furnace Brook at New Ipswich. A 6 foot or greater depth of flooding at these two houses might be expected, while 2 or 3 other houses in New Ipswich roughly 400 feet south of the stream would experience flooding up to 3 or 4 feet deep.

As with the road crossing shortly downstream of the dam, the roadway which crosses Furnace Brook at New Ipswich would be overtopped prior to dam failure, and would be severely damaged or completely destroyed following dam failure.

The dam failure flood wave would be further attenuated as it continued downstream of New Ipswich, particularly where substantial temporary storage is available over relatively flat, open fields which adjoin Furnace Brook just beyond New Ipswich, and again at the confluence with the Souhegan River about a mile further downstream. Nevertheless, the flood wave should still be significant in the Souhegan River at the Otis Company Dam No. 1 in Greenville, 1-1/2 miles downstream of Furnce Brook. The consequences of possible damage or failure to this dam are considered in a separate inspection report on the Otis Company Dam No. 1.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

There has been no significant displacement or distress which would warrant the preparation of structural stability calculations.

(b) Design and Construction Data

1) Embankment

Analysis carried out during the design phase included a slope stability check by a Swedish circle method. Slopes of 2.5 horizontal to 1 vertical upstream and 2 horizontal to 1 vertical downstream were shown to be stable under full drawdown.

2) Appurtenant Structures

A review of the structural calculations for the design of the drop inlet service spillway structure and the outlet conduit (principal spillway) revealed that these structures have been designed on the basis of sound engineering practice.

(c) Operating Records

There are no known operating records for the dam.

(d) Post Construction Changes

There have been no known construction changes since the dam was completed in 1964.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase 1 guidelines, does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The dam and its appurtenances are in GOOD condition at the present time.

(b) Adequacy of Information

There is sufficient design and construction data to permit an asssessment of dam safety when combined with the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The remedial measures described herein should be implemented by the owner within two years of receipt of this Phase I inspection report.

(d) Need for Additional Investigation

None

7.2 Recommendations

No conditions were observed which would warrant further investigations.

7.3 Remedial Measures

It is recommended that the owner institute the following remedial measures:

1) Check the operability of the pond drain gate as part of the annual inspection procedure.

2) Remove shrubs or saplings, including the roots, from slopes. Backfill the resulting voids with suitable compacted material.

3) Develop a formal written downstream emergency flood warning system.

4) Maintain the program of annual technical inspections.

5) Implement and intensify a program of diligent and periodic maintenance including, but not limited to: Mowing embankment slopes; backfilling drainage gullies, tire ruts, and animal burrows with suitable, well tamped soil; and clearing debris from trash racks.

7.4 Alternatives

There are no meaningful alternatives to the above recommendations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: April 30, 1979

Project: NH 00433
SOUHEGAN RIVER WATERSHED PROJECT
Floodwater Retarding Dam No. 14
New Ipswich, New Hampshire
NHWRB 175.01

Weather: Sunny, warm

INSPECTION TEAM

Nicholas A. Campagna	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD)	Team Captain
William S. Zoino	GZD	Soils
M. Daniel Gordon	GZD	Soils
Jeffrey Hardin	GZD	Soils
Paul Razgha	Andrew Christo Engineers (ACE)	Structural
Carl Razgha	ACE	Structural
Thomas Gooch	Resource Analysis, Inc. (RAI)	Hydrology
Richard Laramie	RAI	Hydrology

Owner's Representative Present

Gary Kerr, New Hampshire Water Resources Board

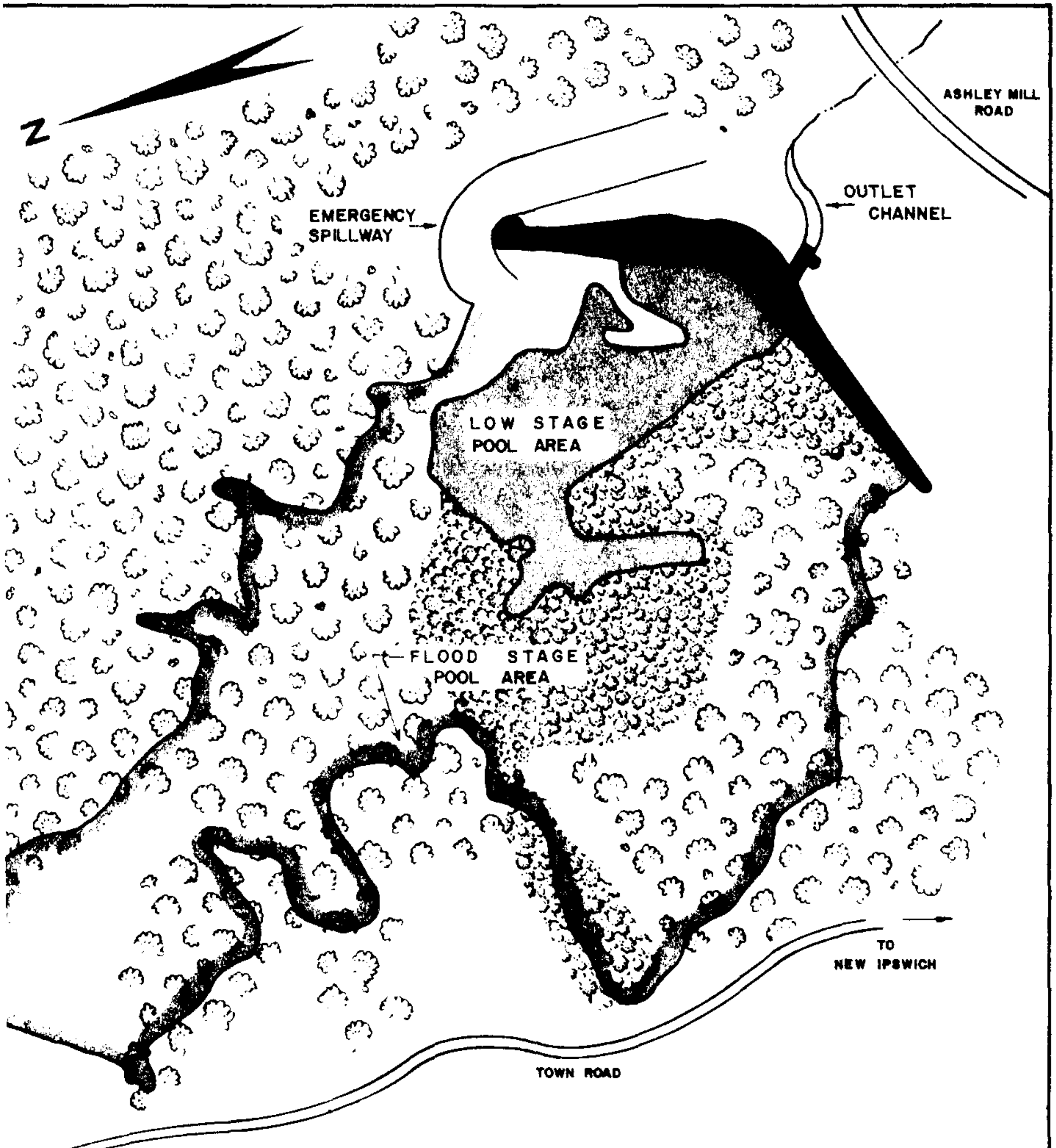
CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
DAM EMBANKMENT		
Crest elevation	NAC	1076.5 ft.
Current pool elevation		1061.7 ft.
Maximum impoundment to date		No data
Surface cracks		None
Pavement condition		Not applicable
Movement or settlement of crest		None
Lateral movement		None
Vertical alignment		Good
Horizontal alignment		Good
Condition at abutment and at concrete structures		Good
Indications of movement of structural items on slopes		None
Trespassing on slopes		5-10 rodent holes 2-6" diameter U/S and D/S, tire ruts 8-10" deep upstream right of outlet; 3-5 small shrubs & trees
Sloughing or erosion of slopes of abutments		None
Rock slope protection - Riprap failures		None - upstream slope in good condition
Unusual movement or cracking at or near toes	NAC	None

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
DAM EMBANKMENT - cont.		
Unusual embankment or downstream seepage	NAC	None
Piping or boils		None
Foundation drainage features		Toe drains as below
Toe drains		Left toe drain 5 gpm flows clear; right toe drain 10-20 gpm
Instrumentation system	NAC	None
APPURTENANT STRUCTURES		
A. Drop Inlet Service Spillway Structure		
Condition of concrete	PR	Good
Spalling		None noted
Erosion		None noted
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Trash Racks		
Upper stage trash racks		No deficiencies noted
Lower stage trash rack		No deficiencies noted
Gate bench stand	PR	No deficiencies noted

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
B. Pond Drain Inlet Pipe	PR	Submerged, could not be observed
C. Outlet Conduit (Primary Spillway)		
Condition of pipe		No deficiencies noted
D. "T" Bent and Cradle	PR	Bottom of bent spalled over entire length 3" x 3". Bottom of cradle spalled 1" x 1".

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

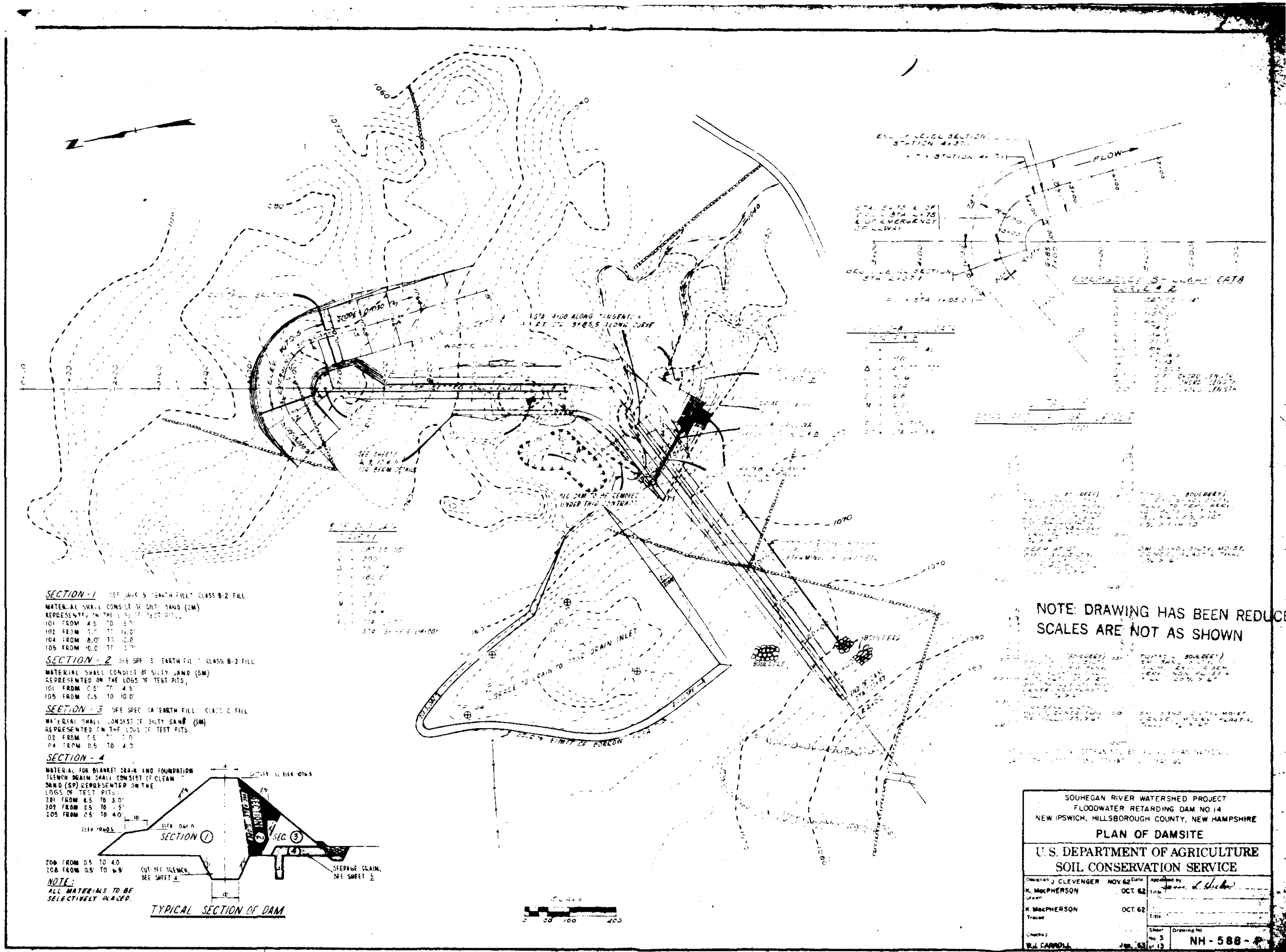
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

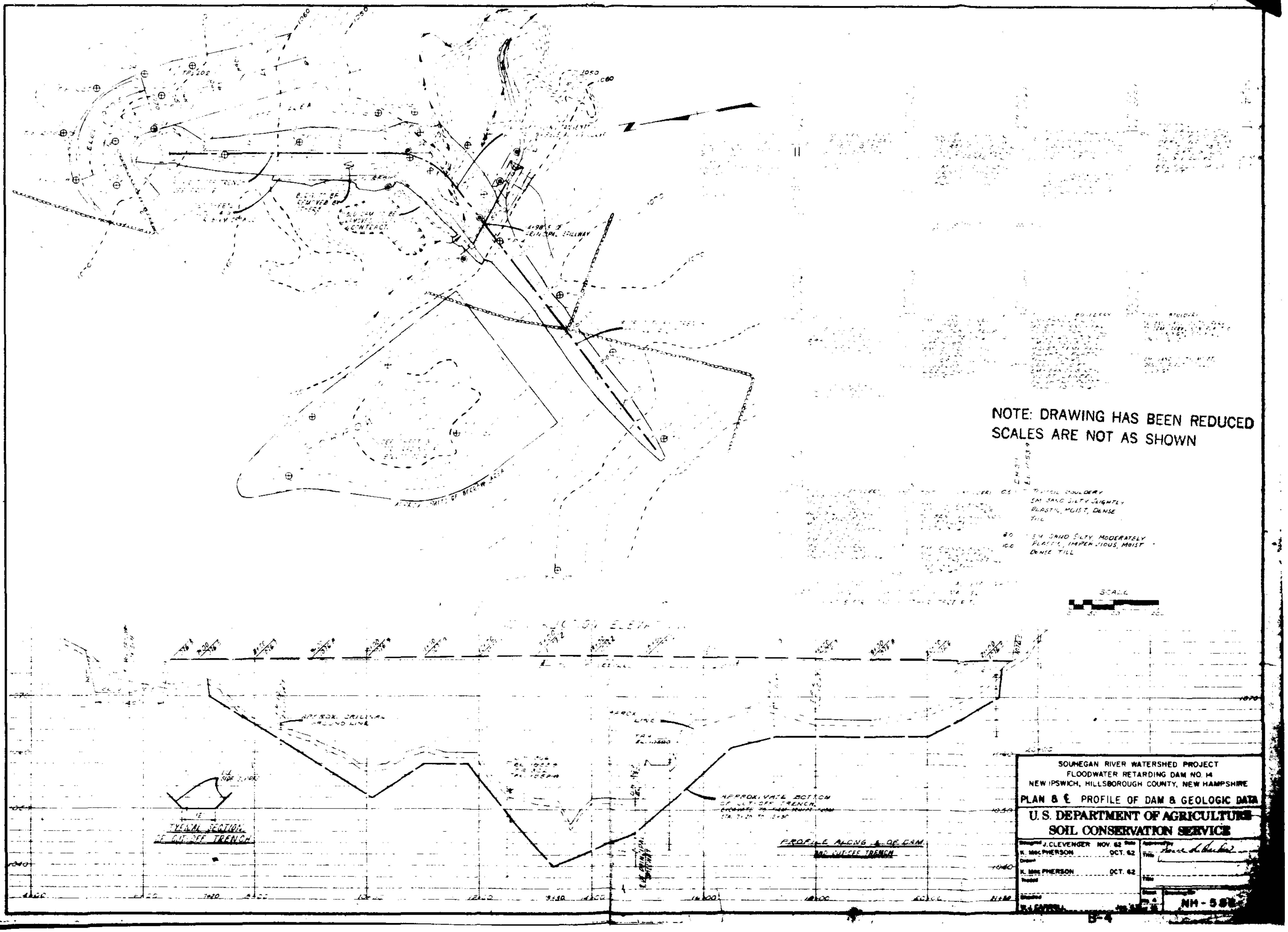
SITE PLAN

SOUHEGAN RIVER WATERSHED
DAM No. 14

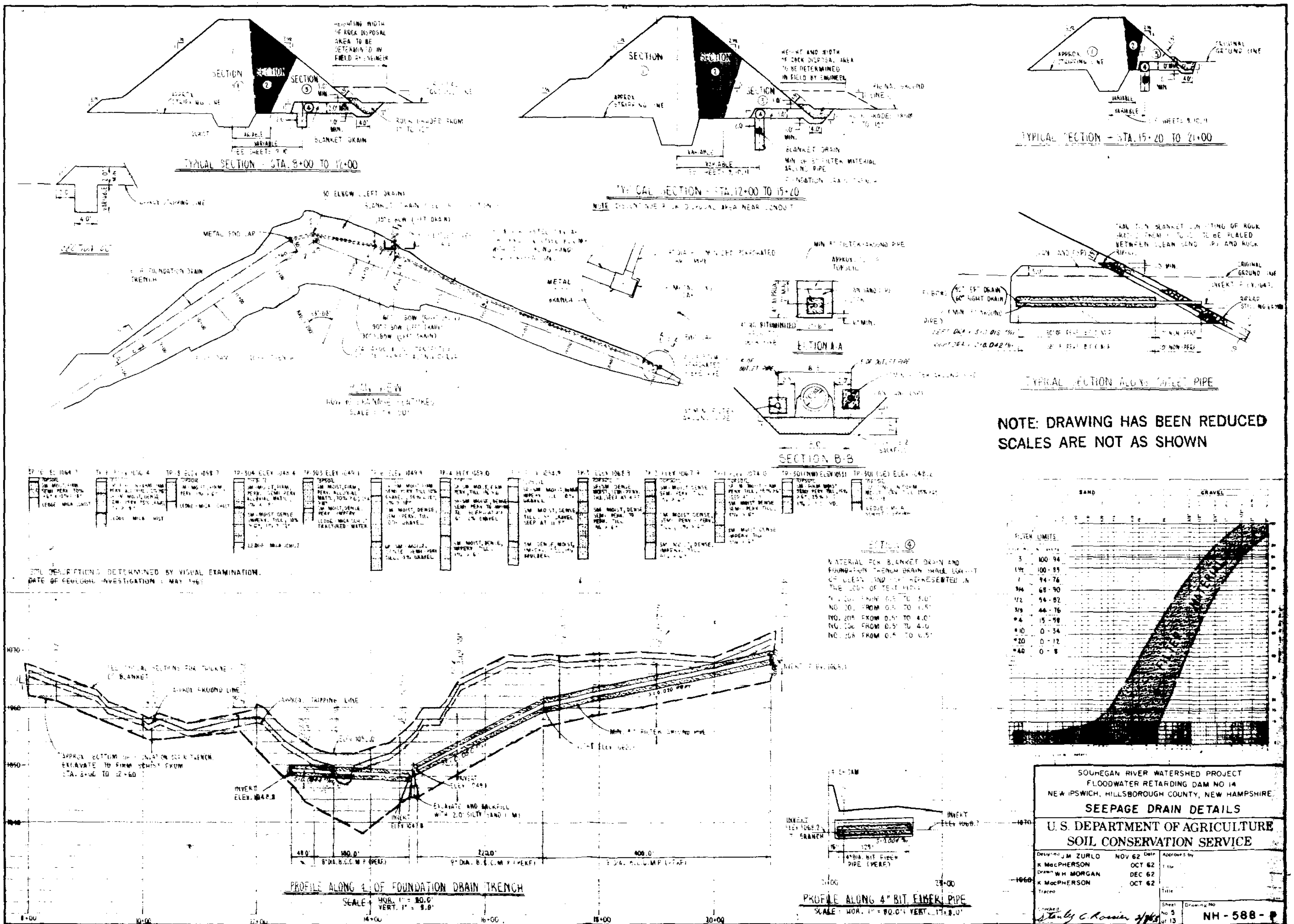
FILE No. 2327

SCALE 1" = 400'
DATE MAY 1979

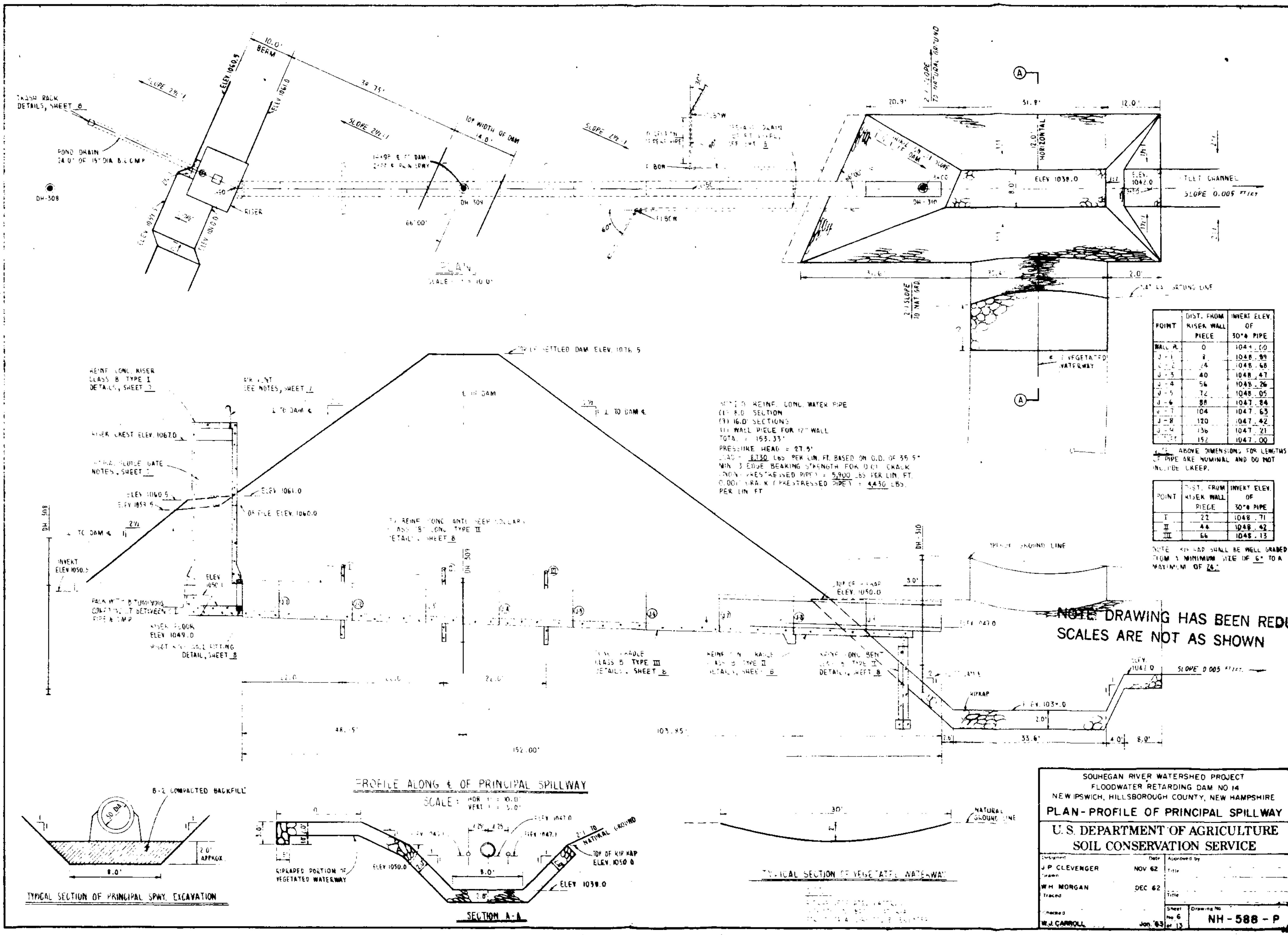

NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN
FLOW
LIMIT OF BORROW AREA
GRADE TO DRAIN TO POND DRAIN INLET
BOULDERS
SEE SHEETS 4, 9, 10 & 11 FOR BERM DETAILS
OLD DAM TO BE REMOVED UNDER THIS CONTRACT
SECTION - 1 SEE SPEC 5 "EARTH FILL" CLASS B-2 FILL
MATERIAL SHALL CONSIST OF SILTY SAND (SM)
SECTION - 2 SEE SPEC 5 "EARTH FILL" CLASS B-2 FILL
MATERIAL SHALL CONSIST OF SILTY SAND (SM)
REPRESENTED ON THE LOGS OF TEST PITS,
101 FROM 0.5' TO 4.5'
105 FROM 0.5' TO 10.0'
SECTION - 3
MATERIAL SHALL CONSIST OF SILTY SAND (SM)
REPRESENTED ON THE LOGS OF TEST PITS.
SECTION - 4
MATERIAL FOR BLANKET DRAIN AND FOUNDATION TRENCH DRAIN SHALL CONSIST OF CLEAN SAND (SP) REPRESENTED ON THE LOGS OF TEST PITS:
201 FROM 0.5 TO 3.0'
205 FROM 0.5' TO 4.0'
206 FROM 0.5 TO 4.0
208 FROM 0.5' TO 6.5'
NOTE:
ALL MATERIALS TO BE SELECTIVELY PLACED.
SECTION ①
SEC. ③
CUT-OFF TRENCH, SEE SHEET 4
SEEPAGE DRAIN, SEE SHEET 5
TYPICAL SECTION OF DAM
SCALE
0 50 100 200
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 14
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
PLAN OF DAMSITE
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed J CLEVENGER NOV 62 Date
K. MacPHERSON OCT. 62
Drawn
K. MacPHERSON OCT. 62
Traced
Checked
W.J. CARROLL
Approved by
Title
Title
Sheet No. 3 of 13
Drawing No
NH-588-



NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN
TYPICAL SECTION
OF CUT-OFF TRENCH
PROFILE ALONG ℄ OF DAM
AND CUT-OFF TRENCH
SCALE
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 14
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
PLAN & ℄ PROFILE OF DAM & GEOLOGIC DATA
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
J. CLEVENGER NOV. 62
K. MacPHERSON OCT. 62
K. MacPHERSON OCT. 62
NH-5
B-4


TYPICAL SECTION - STA. 8+00 TO 12+00
TYPICAL SECTION - STA. 12+00 TO 15+20
TYPICAL SECTION - STA. 15+20 TO 20+00
SECTION A-A
SECTION B-B
TYPICAL SECTION ALONG OUTLET PIPE
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN
SOIL DESCRIPTIONS DETERMINED BY VISUAL EXAMINATION.
DATE OF GEOLOGIC INVESTIGATION : MAY 1962
PROFILE ALONG ₵ OF FOUNDATION DRAIN TRENCH
PROFILE ALONG 4" BIT. FIBER PIPE
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 14
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
SEEPAGE DRAIN DETAILS
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
J.M. ZURLO NOV 62
K. MacPHERSON OCT 62
W.H. MORGAN DEC 62
K. MacPHERSON OCT 62
NH-588-P

Form SCS-317



POINT	DIST. FROM RISER WALL PIECE	INVERT ELEV. OF 30"⌀ PIPE
WALL PC.	0	1049.00
J - 1	8	1048.89
J - 2	24	1048.68
J - 3	40	1048.47
J - 4	56	1048.26
J - 5	72	1048.05
J - 6	88	1047.84
J - 7	104	1047.63
J - 8	120	1047.42
J - 9	136	1047.21
OUTLET	152	1047.00

NOTE: ABOVE DIMENSIONS FOR LENGTHS OF PIPE ARE NOMINAL AND DO NOT INCLUDE CREEP.

POINT	DIST. FROM RISER WALL PIECE	INVERT ELEV. OF 30"⌀ PIPE
I	22	1048.71
II	44	1048.42
III	66	1048.13

NOTE: RIP RAP SHALL BE WELL GRADED FROM A MINIMUM SIZE OF 6" TO A MAXIMUM OF 24".

SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 14
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE

PLAN - PROFILE OF PRINCIPAL SPILLWAY

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed: J P CLEVENGER	Date: NOV 62	Approved by	
Drawn: W H MORGAN	DEC 62	Title	
Traced		Title	
Checked: W.J. CARROLL	Jan. '63	Sheet No 6 of 13	Drawing No NH - 588 - P

Form SCS-313

GENERAL NOTES:

1. ALL CONCRETE SHALL BE CLASS "B" AND OF THE TYPE NOTED.
2. PORTLAND CEMENT TYPE IIA OR TYPE II WITH AN AIR-ENTRAINING ADMIXTURE SHALL BE USED.
3. ALL REINFORCING STEEL TO BE LAPPED A MIN OF 30 BAR DIAMETERS.
4. ALL REINFORCING STEEL PLACED IN CONCRETE POURED AGAINST THE GROUND SHALL HAVE A MIN. OF 3" CLEAR COVER. WHERE FORMS ARE USED BARS SHALL A MIN. OF 2 CLEAR COVER.
5. ALL EXPOSED EDGES OF CONCRETE TO HAVE A 3/4 CHAMFER UNLESS OTHERWISE NOTED.

QUANTITY SUMMARY

THIS SHEET ONLY:

CONCRETE:
CLASS "B" TYPE I = 23.6 CU. YDS.

REINF. STEEL:
Nº 5 BARS = [illegible] LIN. FT = [illegible] LBS.
Nº 6 BARS = [illegible] LIN. FT = [illegible] LBS.

JOB TOTAL:

CONCRETE:
CLASS "B" TYPE I = 23.6 CU. YDS.
TYPE II = 12.7 CU. YDS.
TYPE III = 76.5 CU. YDS.

REINF. STEEL:
Nº 4 BARS = [illegible] LIN. FT = [illegible] LBS.
Nº 5 BARS = [illegible]7.93 LIN. FT = [illegible]295 LBS.
Nº 8 BARS = [illegible] LIN. FT = [illegible]4 LBS.
[illegible] BARS = [illegible] LIN. FT = [illegible] LBS.
Nº 6 BARS = 233.75 LIN. FT = 351 LBS.
TOTAL [illegible]68 LBS.

STEEL SCHEDULE

MARK	LOCATION	QUAN.	SIZE	LENGTH	TYPE	A	B	C	TOTAL FT.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

STEEL SCHEDULE

MARK	LOCATION	QUAN.	SIZE	LENGTH	TYPE	A	B	C	TOTAL FT.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

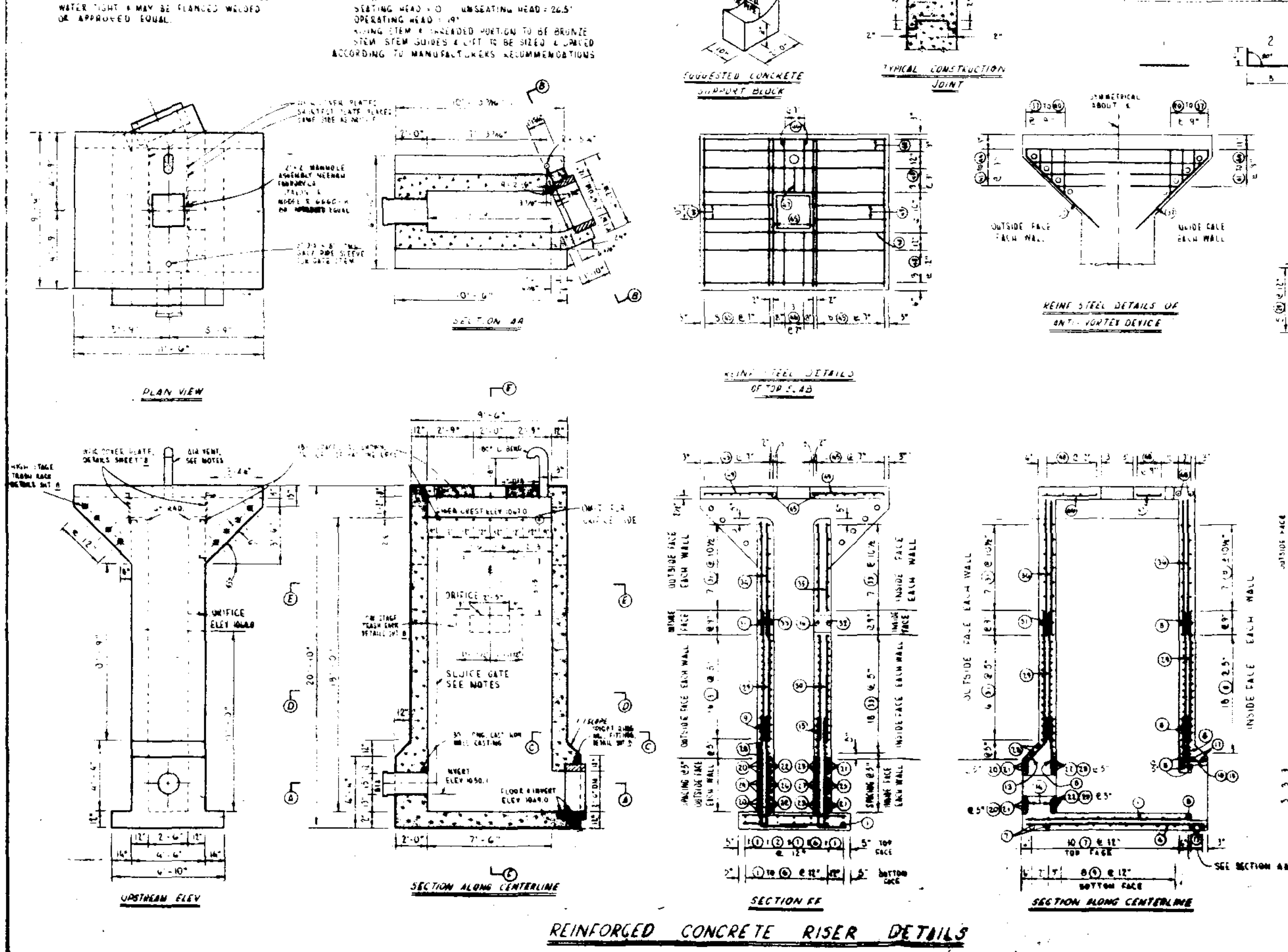
AIR VENT NOTES

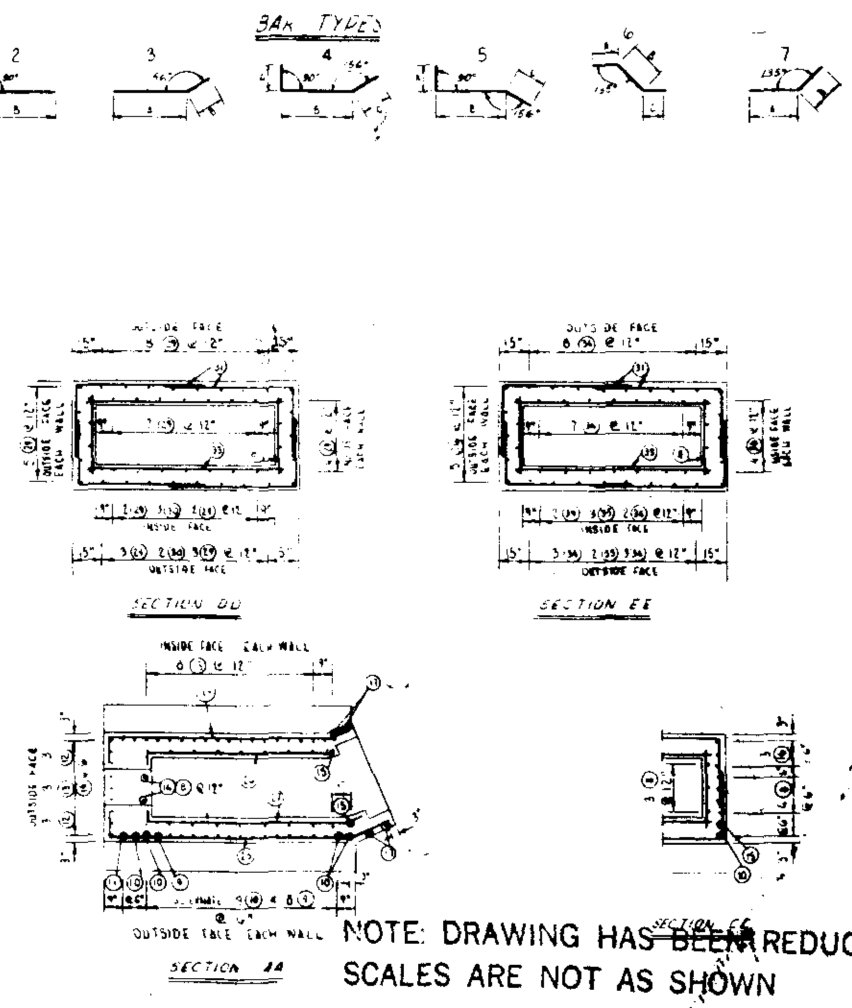
1. PIPE TO BE STANDARD 4" DIA. WELDED OR SEAMLESS STEEL.

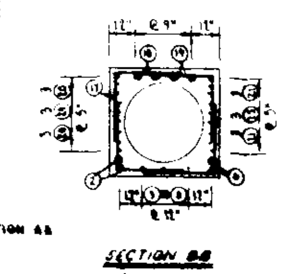
2. PIPE & ELBOW CONNECTIONS SHALL BE WATER TIGHT & MAY BE FLANGED, WELDED OR APPROVED EQUAL.

SLUICE GATE NOTES

1. [illegible] DIA. SLUICE GATE RODNEY HUNT SERIES 160 FLANGE FRAME OR EQUAL.
[illegible] DIA. 30" LONG FLANGE & BELL CAST IRON WALL CASTING.
SEATING HEAD = 0 UNSEATING HEAD = 26.5'
OPERATING HEAD = 19'
RISING STEM & THREADED PORTION TO BE BRONZE.
STEM, STEM GUIDES & LIFT TO BE SIZED & SPACED ACCORDING TO MANUFACTURERS RECOMMENDATIONS.







REINFORCED CONCRETE RISER DETAILS

NOTE: DRAWING HAS BEEN REDUCED SCALES ARE NOT AS SHOWN

SCALE 1/4" = 1'-0"

SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 14
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE

RISER DETAILS

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
J. P. CLEVENGER	NOV 62	Title
Drawn		
[illegible]	[illegible]	
Traced		
Checked		Sheet No. 7 of 13
D. J. GER[illegible]NA	NOV 62	Drawing No. NH-5[illegible]

The U.S.D.A. Soil Conservation Service (SCS) located in Durham, New Hampshire, maintains a file for this dam. Included in this file are:

1) SCS "Design Report" dated 12/12/62.

2) SCS "Hydrology and Hydraulics" design calculations dated 1962.

3) SCS structural design calculations dated 1962.

4) SCS "Detailed Geological Investigation of Dam Sites" dated 1962.

5) SCS Soil mechanics laboratory data sheets dated August, 1962.

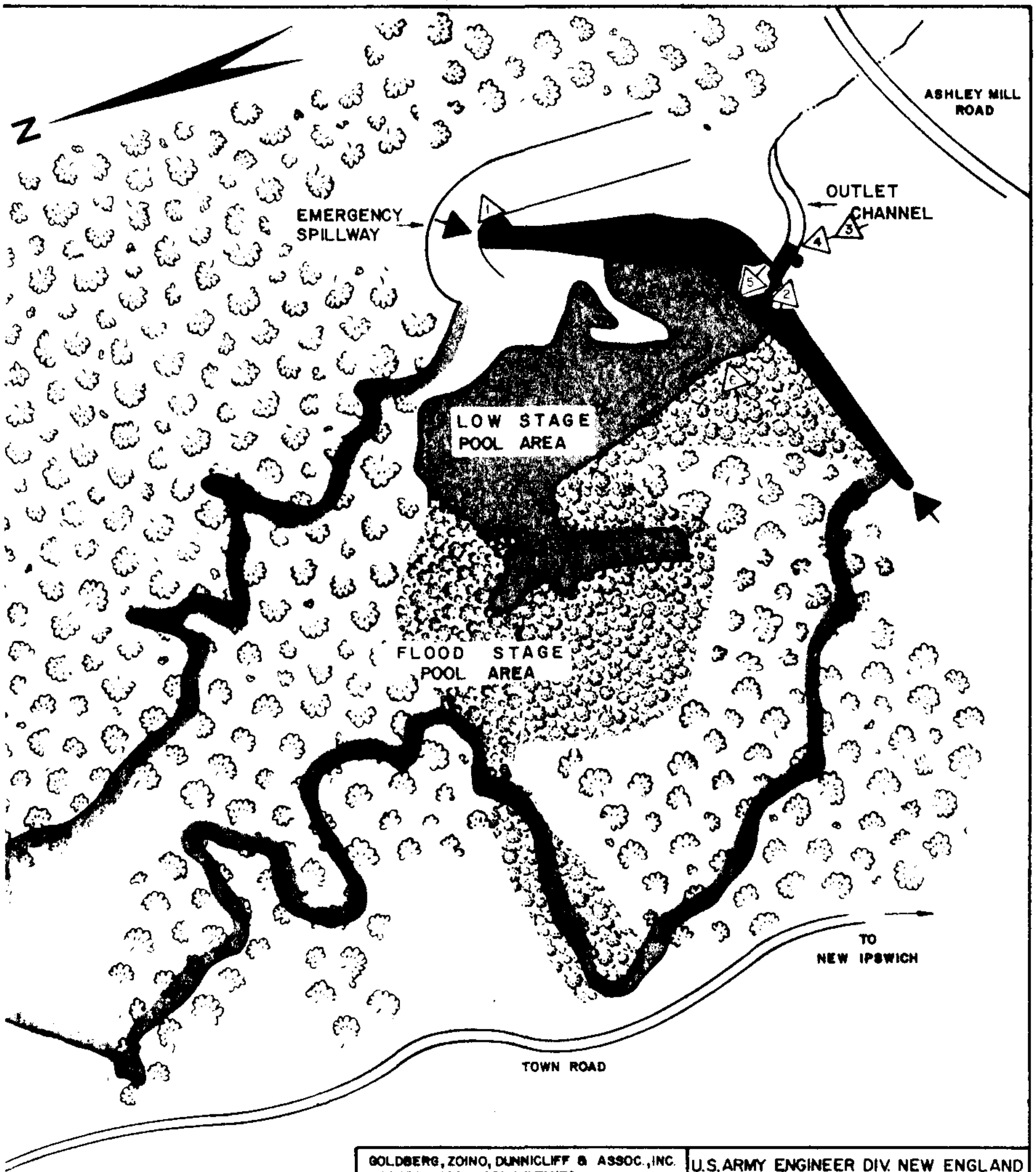
6) SCS "As Built" drawings dated 1963.

The New Hampshire Water Resources Board (NHWRB) maintains a correspondence file on this dam. Included in this file are:

1) Maintenance inspection checklists dated May 19, 1977 and June 16, 1978.

APPENDIX C

SELECTED PHOTOGRAPHS



OVERVIEW

APPENDIX C

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND ORIENTATION OF PHOTOS

SOUHEGAN RIVER WATERSHED
DAM No. 14 NEW HAMPSHIRE

FILE No. 2327

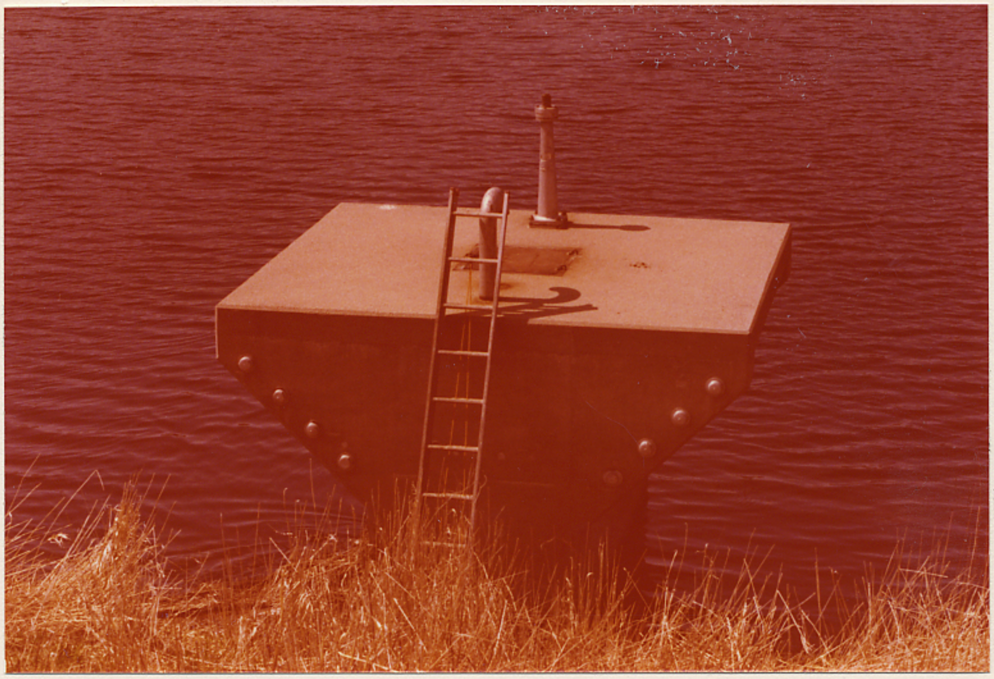
SCALE 1" = 400'
DATE MAY 1979

1. View of emergency spillway channel from the left end of the earth embankment

2. View of downstream channel and outlet pipe from the downstream toe.

3. View of outlet pipe from downstream

4. Detail view of outlet pipe support showing spalling of tree bent and cradle



5. View of drop inlet structure showing bench stand and vent pipe

6. View of drop inlet structure showing trash racks

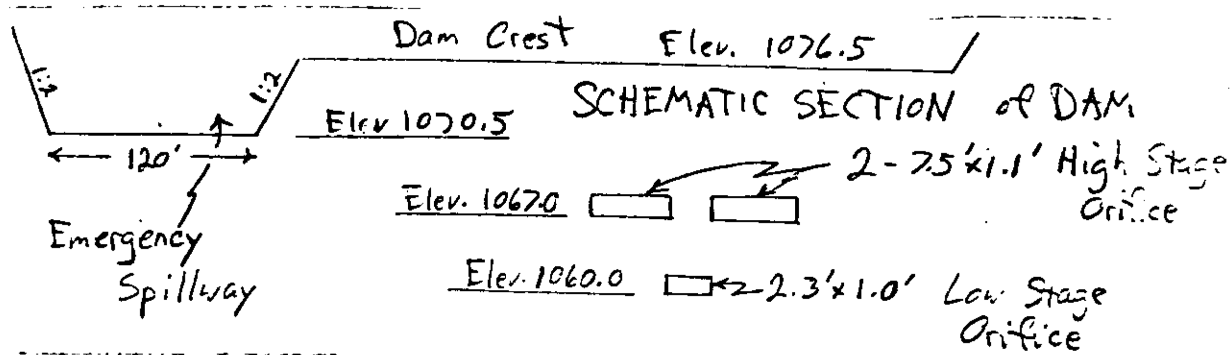
APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

I Dam Rating Curve

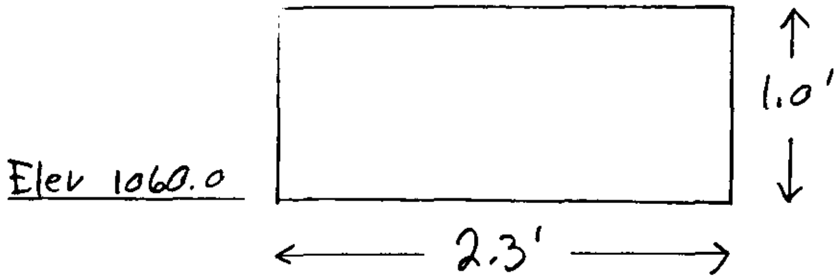
Three separate outlets have been provided for this dam: a low stage orifice, a pair of high stage orifices, and a grass lined emergency spillway channel. Flow from the high and low stage orifices enters a single riser (2.5'x 7.5') which is drained by a 152' long 30"ϕ RC pipe. This system is designed so that flowrate is controlled by the orifices rather than by the 30"ϕ drain pipe, except at high stages.*

The stage-discharge function of each outlet will be considered separately. The rating tables provided by the SCS for the high and low stage outlets as part of the design calcs. apply to a different configuration than that shown in the design drawings and so cannot be used here.



* At high stages, principal spillway discharge is negligible compared to emergency spillway flows.

Low Stage Outlet



Datum -- Elev. 1060.0

$H = 0$ to $H = 1.0$

$Q = C_w L H^{3/2}$ (overflow weir eq.)

$C_w = 3.3$ (sharp crested weir)

$L = 2.3'$

$Q = 3.3 * 2.3 * H^{3/2}$

$H > 1.0$

$Q = C_o A \sqrt{2g H_{orifice}}$

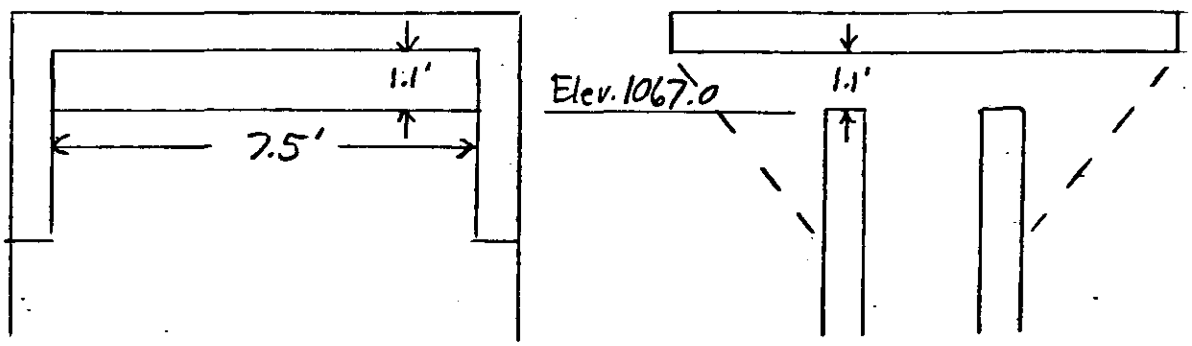
$C_o = 0.6$

$A = 2.3'^2$

$H_{orifice} = H - 0.5'$ (head on centroid)

$Q = 0.6 * 2.3 * (2 * g * (H - 0.5))^{1/2}$

High Stage Outlet



Datum -- Elev. 1060.0

$H \leq 7.0$

$Q = 0$

$H = 7.0$ to $H = 8.1$

$Q = (C_w L H_w^{3/2}) \times 2$

$C_w = 3.3$

$L = 7.5'$

$H_w = H - 7.0$

$Q = (3.3 * 7.5 * (H - 7.0)^{3/2}) \times 2$

$H > 8.1$

$Q = (C_o A \sqrt{2g\, H_{orifice}}) \times 2$

$C_o = 0.6$

$A = 7.5 \times 1.1 = 8.25$

$H_{orifice} = H - 7.55$

$Q = (0.6 * 8.25 * (2 * g * (H - 7.55))^{1/2}) \times 2$

A simple BASIC program was used to compute a rating table for the principal spillway as follows,

```
LIST
100 REM: STORED ON TAPE 18, FILE 52
110 REM: STAGE-DISCHARGE FUNCTION FOR S.W.D. #14
120 PAGE
130 PRINT "DISCHARGE FROM S.W.D. #14"
140 PRINT USING 150:
150 IMAGE /2T"HEAD"4X"ELEV" 30T"DISCHARGE"
160 PRINT USING 170:
170 IMAGE 1T"(FEET)" 32T"(CFS)"
180 PRINT USING 190:
190 IMAGE 17T"   TOTAL            LOW STAGE     HIGH STAGE"
200 FOR H=0 TO 17 STEP 1
205 E1=1060+H
210 Q1=3.3*2.3*H↑1.5
220 Q2=0
230 IF H<=1 THEN 290
240 Q1=0.6*2.3*(2*32.2*(H-0.5))↑0.5
250 IF H<=7 THEN 290
260 Q2=2*3.3*7.5*(H-7)↑1.5
270 IF H<=8.1 THEN 290
280 Q2=2*0.6*8.25*(2*32.2*(H-7.55))↑0.5
290 Q3=Q1+Q2
300 PRINT USING 310:H,E1,Q3,Q1,Q2
310 IMAGE 2T,2D.2D,6D.2D,7D,6X,10D,3X,10D
320 NEXT H
330 END
```

4/24

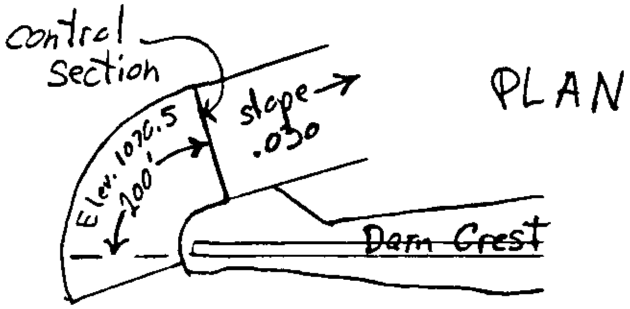
DISCHARGE FROM S.W.D. #14 (PRINCIPAL SPILLWAY ONLY)

HEAD (FEET)	ELEV	DISCHARGE (CFS) TOTAL	LOW STAGE	HIGH STAGE
0.00	1060.00	0	0	0
1.00	1061.00	8	8	0
2.00	1062.00	14	14	0
3.00	1063.00	18	18	0
4.00	1064.00	21	21	0
5.00	1065.00	23	23	0
6.00	1066.00	26	26	0
7.00	1067.00	28	28	0
8.00	1068.00	80	30	50
9.00	1069.00	128	32	96
10.00	1070.00	158	34	124
11.00	1071.00	183	36	148
12.00	1072.00	205	38	168
13.00	1073.00	225	39	185
14.00	1074.00	242	41	202
15.00	1075.00	259	42	217
16.00	1076.00	275	44	231
17.00	1077.00	289	45	244

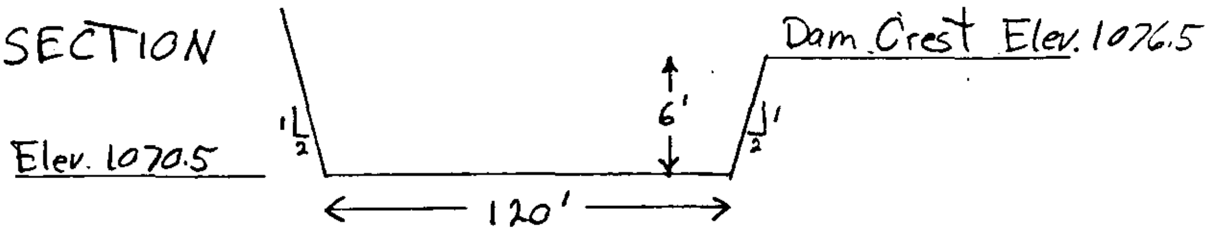
HEAD IS MEASURED FROM CREST OF LOW STAGE ORIFICE

5/24

Emergency Spillway



X-SECTION



Weir flow will be assumed at the control section. For a given discharge, the H at the control section must be adjusted by a backwater compution to determine the water surface elev. 200' upstream at the dam crest. This adjustment will be made using SCS, T.R. 39, assuming Manning's $n = 0.04$

Datum -- elev. 1060.0

$H \leq 10.5$

$Q = 0$

$H = 10.5'$ to $H = 16.5'$

$$Q = C_w L H_{cs.}^{3/2} + 2 * C_w * (2 * H_{cs}) (.5 H_{cs.})^{3/2}$$

$C_w = 3.1$

$L = 120'$

$H_{cs.}$ = head at control section

$$Q = 3.1 * 120 * H_{cs}^{3/2} + 2 * 3.1 * (2 * H_{cs}) (.5 H_{cs})^{3/2}$$

$h_{cs.}$ **	Q	h_p.** (200' W/S) *	$H^{‡} = h_p + 10.5$
0	0	0	10.5
1	376	1.6	12.1
2	1078	2.8	13.3
3	2002	3.9	14.4
4	3116	5.0	15.5
5	4404	6.0	16.5
6	5854	7.1	17.6

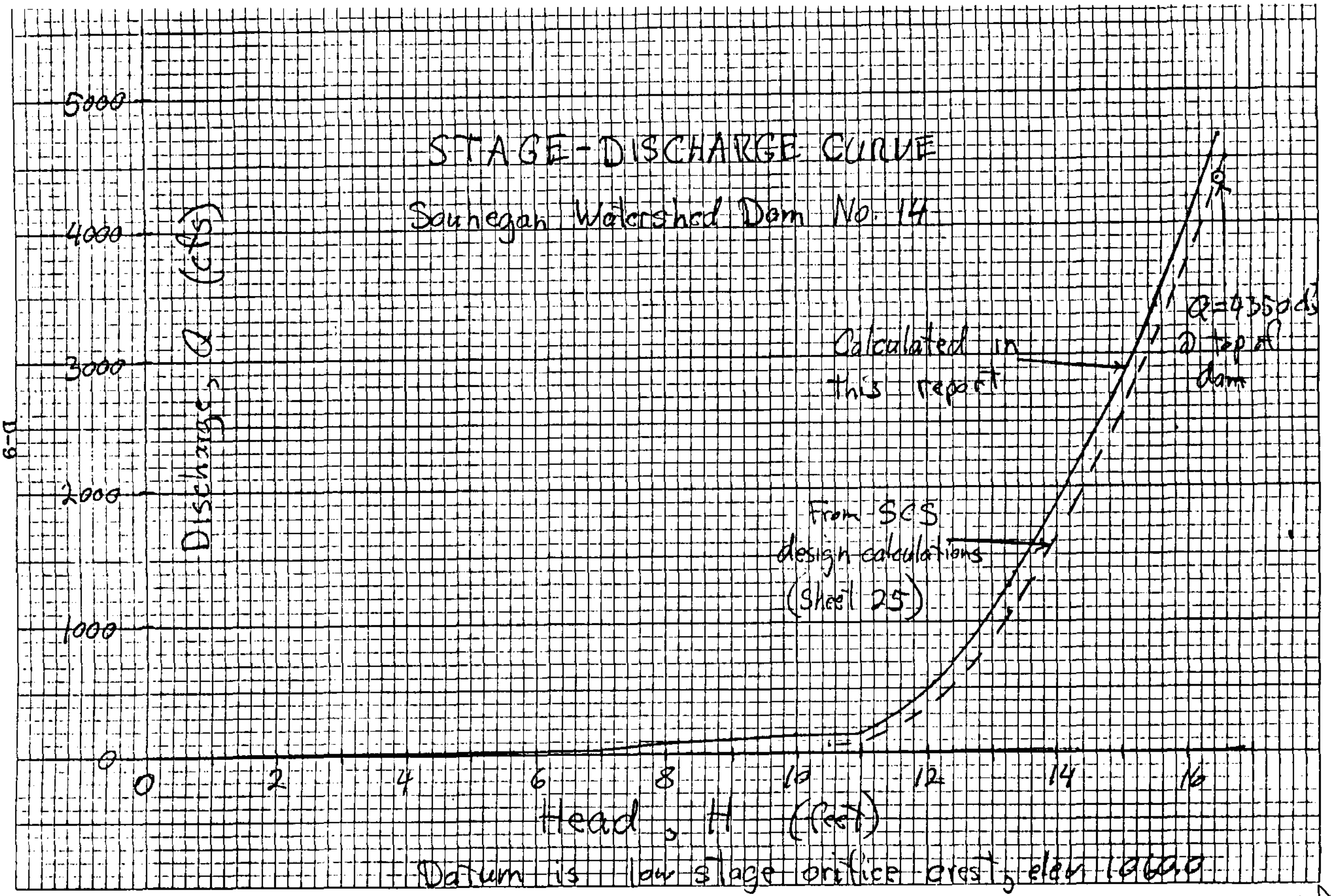
Datum = Elev.

* ES-171 in SCS, TR 39

** Head on emergency spillway crest, elev. 1070.5

‡ Head of pool above Low Stage orifice crest, Elev. 1060.0

A stage-discharge curve is shown on the following page, which includes the combined emergency and principal spillway outflows.

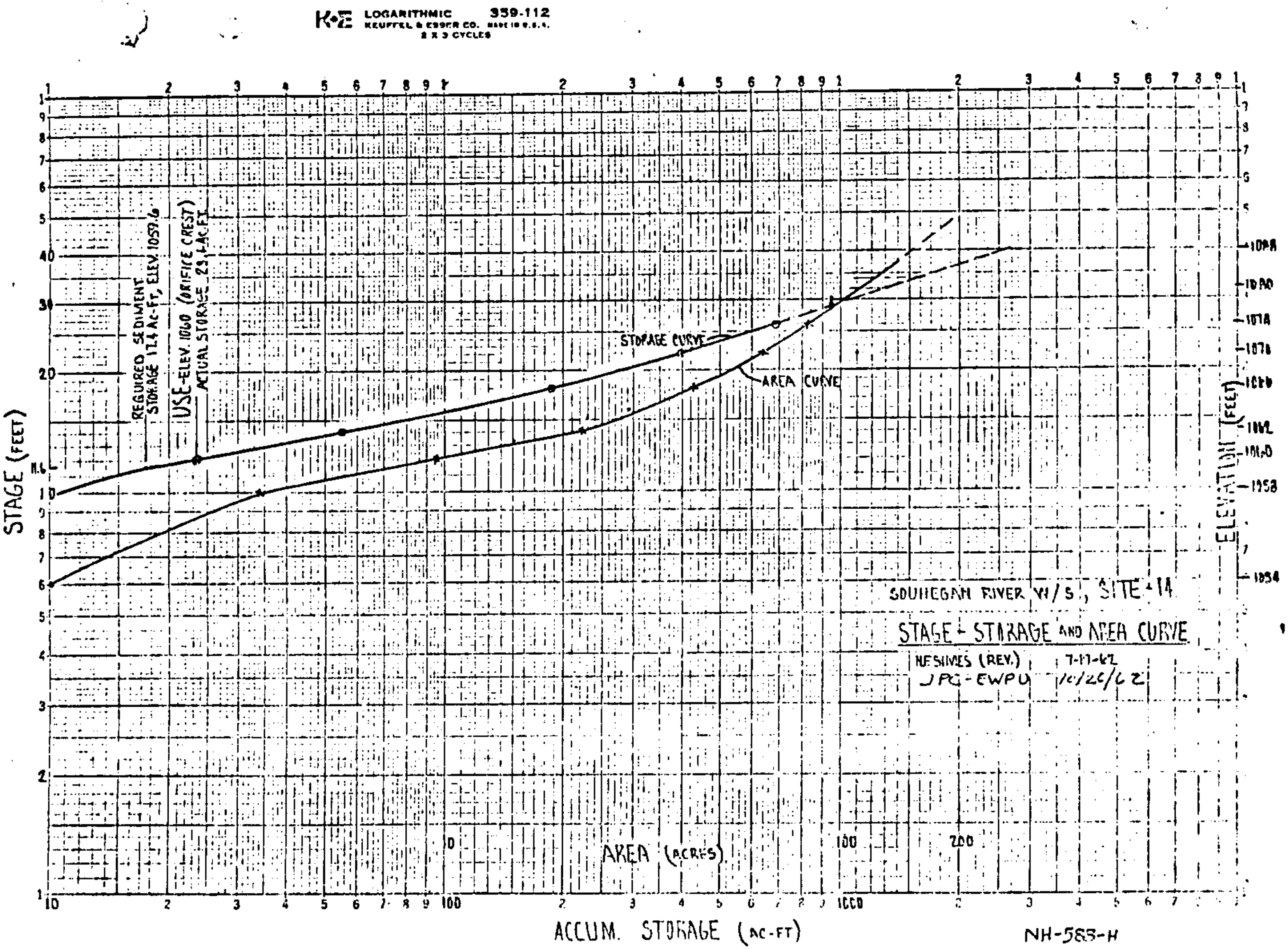


STAGE-DISCHARGE CURVE
Souhegan Watershed Dam No. 14
Discharge, Q (cfs)
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
14
16
Head, H (feet)
Datum is low stage orifice crest, elev 1066.0
Q=4350 cfs @ top of dam
Calculated in this report
From SCS design calculations (Sheet 25)

Note from the stage-discharge curves that the dam rating calculated in this report does not differ significantly from that developed on sheet 25 in the SCS design calculations for this dam. Subsequent computations will be based on the SCS dam rating values.

Stage- Storage Function

A copy of the stage-storage and stage-surface area curves computed and drawn by the SCS as part of the design calculations is included on the next page.


K+E LOGARITHMIC 359-112
KEUFFEL & ESSER CO.
2 X 3 CYCLES
REQUIRED SEDIMENT STORAGE 17.4 AC-FT, ELEV. 1057.6
USE - ELEV. 1060 (ORIFICE CREST)
ACTUAL STORAGE 23.1 AC.FT.
STORAGE CURVE
AREA CURVE
SOUHEGAN RIVER W/S, SITE 14
STAGE - STORAGE AND AREA CURVE
NESIMES (REV.) 7-17-62
JPC - EWPU 10/26/62
STAGE (FEET)
ELEVATION (FEET)
AREA (ACRES)
ACCUM. STORAGE (AC-FT)
NH-583-H

Dam Failure Analysis

Outflow at failure = Outflow through breach + Normal outflow at failure elev. of pool

Assume that dam fails with the pool at design high water level -- elev. 1074.5

This level has been chosen instead of Top of dam because it is considered more critical in terms of the consequences of dam failure. That is, the normal outflow with the pool at top of dam is so large that considerable damage would result at New Ipswich downstream, and the flood wave due to dam failure would cause only an increment of increased damage which would be hard to reckon.

Also, this does not represent an unrealistic condition at failure, for a dam break might conceivably be initiated by overtopping due to wave run-up, by erosion at the emergency spillway channel due to the high tractive force of flow at this depth, or by other modes. (These phenomena are accounted for in the SCS. design, so these types of failure are not considered likely.)

Normal Outflow

$Q = 2350$ cfs (a.m rating curve, $H = 14.5'$)

Tailwater level at failure

Assume that tailwater is approx. at base of dam -- elev. 1048

- Emergency spillway discharge will flow down steep hillside and join natural brook at a point downstream where stream-bed is approx. 1042 and flowing 5 to 6 feet deep.
- Roadway 500' d/s at elev ~ 1043 will not cause backwater higher than this.

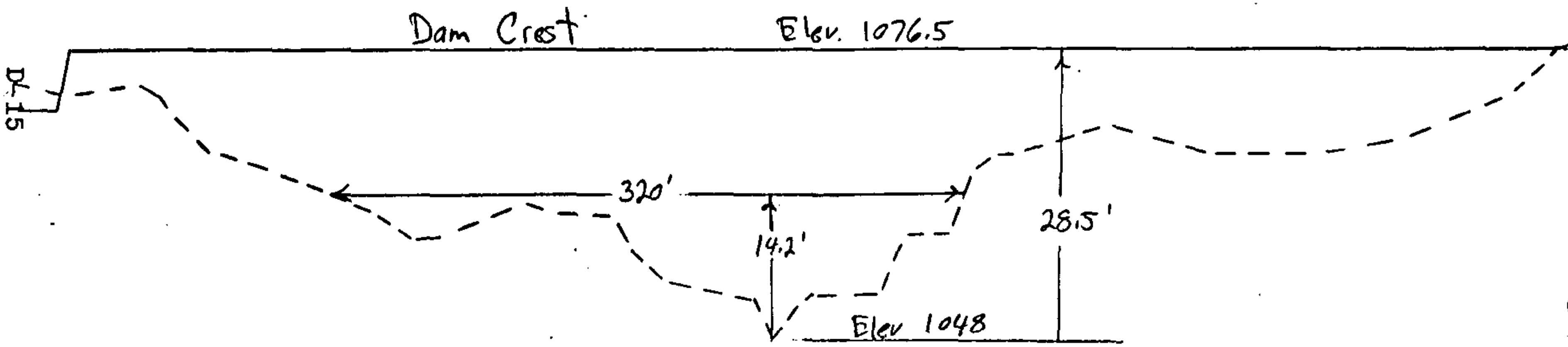
Breach Outflow

$$Q_{p1} = 8/27 \times W_b \times \sqrt{g} \times Y_0^{3/2}$$

W_b = width of breach

$\leq 0.4 \times$ (width of dam at 1/2 height)

use $W_b = .4 \times 320 = 128'$ (see figure next page)



Cross Section of Souhegan Watershed Dam No. 14

No Scale

Dam Safety

SWD #14

RHF
6-1-79

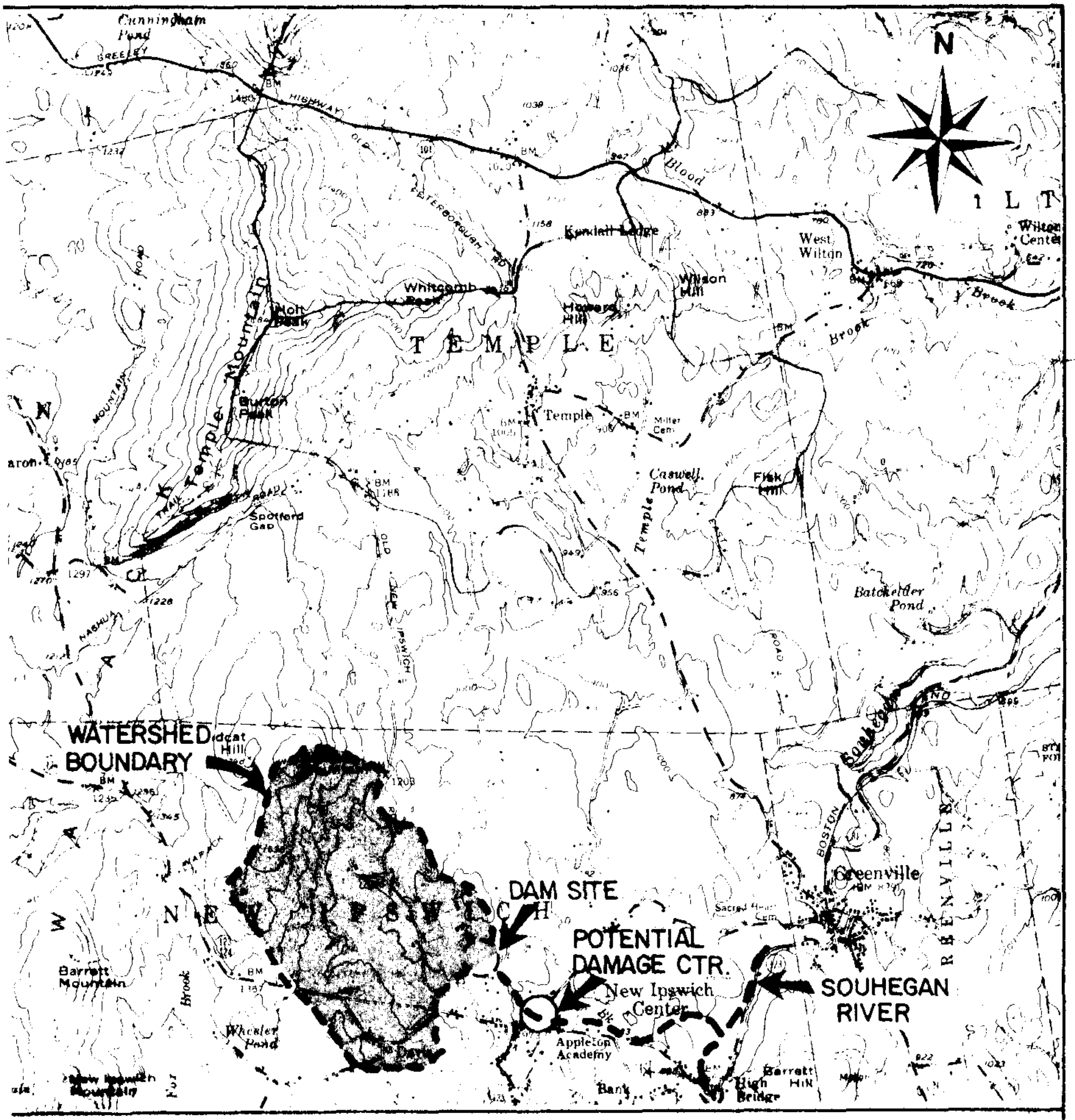
13/24

$Y_0 = 28.5'$

$Q_{pi} = 8/27 \times 128 \times \sqrt{g} \times 28.5^{3/2} = 32700$ cfs

Total Outflow

$Q_{tot} = 32700 + 2400 = 35100$ cfs



- SCALE -

0 1/2 1 2 (Miles)

FROM: USGS PETERBOROUGH - N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION MAP

FILE No. 2327

SOUHEGAN RIVER
WATERSHED DAM No. 14

NEW IPSWICH, NEW HAMPSHIRE

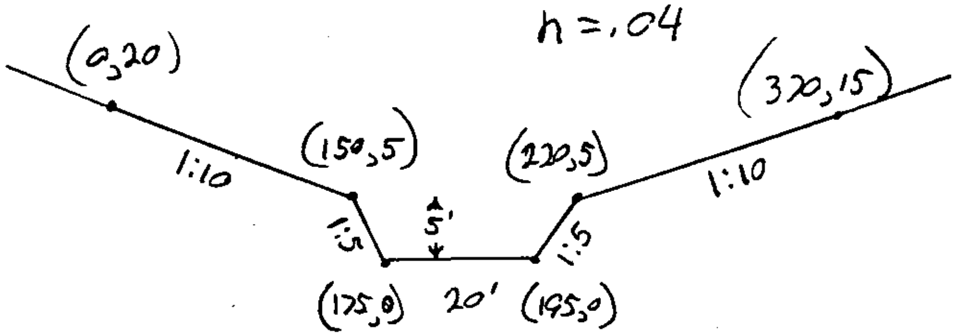
SCALE AS NOTED

DATE

Downstream Flooding

Furnace Brook - typical section d/s of dam
Use for reach from dam to a point outside of New Ipswich 0.4 miles d/s of dam

$S = .02$
$n = .04$



Estimate Peak Flow .4 mile d/s of dam
Follow COE "'Rule of Thumb' Guidance for Estimating Downstream Dam Failure Hydrographs"

A simple BASIC program was used to calculate a rating table for this reach based on the representative section sketched above. The table is shown on the following page.

Storage in Reach vs. Outflow (Q_{p2})
Assume channel storage equal to avg. of u/s flow area (known) and d/s flow area (function of reach outflow) times the reach length. (Does not account for channel volume already taken by steady flow)

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	25.0	30.2	0.8	22.0	116.1
2.0	2.0	60.0	40.4	1.5	78.1	411.5
3.0	3.0	105.0	50.6	2.1	170.9	900.2
4.0	4.0	160.0	60.8	2.6	305.1	1607.2
5.0	5.0	225.0	71.0	3.2	485.7	2558.5
6.0	6.0	307.5	96.1	3.2	668.1	3519.5
7.0	7.0	415.0	121.2	3.4	943.4	4969.8
8.0	8.0	547.5	146.2	3.7	1320.7	6957.1
9.0	9.0	705.0	171.3	4.1	1811.2	9541.5
10.0	10.0	887.5	196.4	4.5	2427.0	12785.1
11.0	11.0	1095.0	221.5	4.9	3179.5	16749.2
12.0	12.0	1327.5	246.6	5.4	4080.1	21493.8
13.0	13.0	1585.0	271.7	5.8	5139.9	27076.9
14.0	14.0	1867.5	296.7	6.3	6369.7	33555.1
15.0	15.0	2175.0	321.8	6.8	7779.7	40983.2
16.0	16.0	2500.0	331.9	7.5	9613.4	50643.1
17.0	17.0	2835.0	341.9	8.3	11621.9	61223.5
18.0	18.0	3180.0	352.0	9.0	13804.7	72722.2
19.0	19.0	3535.0	362.0	9.8	16161.8	85139.4
20.0	20.0	3900.0	372.1	10.5	18693.8	98477.8

STREAM RATING FURNACE BROOK D/S OF S.W.D. #14

12/24

$$Vol = \left(\frac{A_1 + A_2}{2}\right) \times L$$

$L = .4 \times 5280 = 2100'$

$A_1 = 1930'^2$ (from stream rating with $Q_{p1} = 35100$ cfs)

$A_2 = f(Q_{p2})$ (use stream rating table)

Channel Storage vs. Outflow

Q_{p2}	D_2	A_2	Vol (AF)
12800 cfs	10'	$888'^2$	70 AF
16749	11	1095	75
21494	12	1328	81
27077	13	1585	87
33555	14	1868	94
35100	14.3	1930	96

Peak Outflow from Reach

$$Q_{p2} = Q_{p1}\left(1 - \frac{Vol}{S}\right)$$

$Q_{p1} = 35100$ cfs

$S = 700$ AF (vol. behind dam, see Stage-Storage curve)

$$Q_{p2} = 35100\left(1 - \frac{Vol}{700}\right)$$

$$Vol = 700\left(1 - \frac{Q_{p2}}{35100}\right)$$

guess $Q_{p2} = 27100$ cfs

$\Rightarrow Vol = 700\left(1 - \frac{27100}{35100}\right) = 159$

$\Rightarrow Q_{p2} > 27100$ (from Channel Storage vs. Outflow table above)

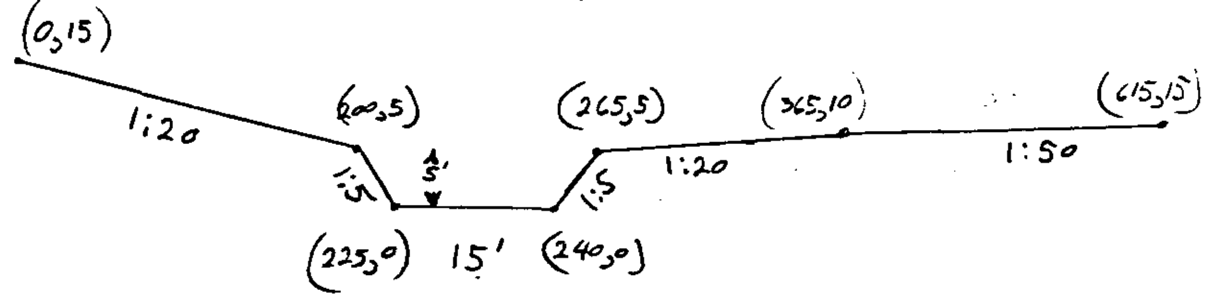
guess $Q_{p2} = 30{,}000$ cfs $\Rightarrow Vol = 101$ AF
guess $Q_{p2} = 31000$ cfs $\Rightarrow Vol = 82$ AF

use $Q_{p2} = \underline{\underline{31500 \text{ cfs}}}$

Estimate Peak Flow at New Ipswich, 0.6 mile d/s of dam

Furnace Brook @ New Ipswich, 0.6 miles d/s
Use for reach from 0.4 miles d/s to 0.6 miles d/s of dam.

$S = .007$
$n = .04$



An approximate rating table for this reach of Furnace Brook based on the sketch above is shown on the following page.

$$Q_{p2} = Q_{p1}\left(1 - \frac{Vol}{S}\right)$$

$$Q_{p1} = 31500 \text{ cfs}$$

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	20.0	25.2	0.8	17.1	53.4
2.0	2.0	50.0	35.4	1.4	63.0	196.2
3.0	3.0	90.0	45.6	2.0	141.7	441.5
4.0	4.0	140.0	55.8	2.5	258.6	805.9
5.0	5.0	200.0	66.0	3.0	419.0	1305.9
6.0	6.0	285.0	106.0	2.7	551.1	1717.6
7.0	7.0	410.0	146.1	2.8	816.0	2543.2
8.0	8.0	575.0	186.1	3.1	1220.1	3802.4
9.0	9.0	780.0	226.2	3.4	1781.1	5550.9
10.0	10.0	1025.0	266.2	3.8	2518.9	7850.5
11.0	11.0	1325.0	336.3	3.9	3307.0	10306.3
12.0	12.0	1695.0	406.3	4.2	4394.6	13696.0
13.0	13.0	2135.0	476.3	4.5	5806.7	18097.1
14.0	14.0	2645.0	546.4	4.8	7573.1	23602.1
15.0	15.0	3225.0	616.4	5.2	9724.6	30307.4

STREAM RATING FURNACE BROOK @ NEW IPSWICH

20/24

$S = 700 - 90 = 610\ AF$

$Vol = \left(\frac{A_1 + A_2}{2} - A_s\right) \times L$

$A_1 = 3300'^2$

$A_s = 400'^2$ (steady flow area)

$L = .4 \times 5280 = 1100'$

Q_{p2}	D_2	A_2	Vol
18100	13	2135	60
23600	14	2645	67
30300	15	3225	74

$Vol = 610\left(1 - \frac{Q_{p2}}{31500}\right)$

guess $Q_{p2} = 27000$ cfs $\Rightarrow Vol = 87$

guess $Q_{p2} = 28000$ cfs $\Rightarrow Vol = 68$

use Q_{p2} = <u>28000</u> cfs

From rating table, depth of flow $\cong 14.7'$

(Depth of flow prior to dam failure $\cong 6.8'$

Two houses adjacent to Furnace Brook at New Ipswich, with first floor levels approx. 6' and 8' above the streambed, would be severely damaged by the dam break flood wave. Other houses in New Ipswich roughly 400' south of the stream, which have first floor levels 10' to 15' above the stream bed, would also be damaged.

Test Flood Analysis

Size Classification -- Small

Storage < 1000 AF

Height < 40'

Hazard Classification -- High

Dam failure would result in serious damage to homes in New Ipswich and possible loss of life.

Test Flood Selection

Per COE guidelines, a Small dam with High hazard potential should use a ½ PMF to PMF Test Flood. As the size of SWD #14 is on the high side of Small, and as the SCS considers it to be a Class C structure, use the PMF.

from COE N.E.D. "Maximum Probable Flood Peak Flow Rates"

Watershed - rolling to mountainous

Drainage Area - 1485 acres = 2.32 sq miles

use PMF = 2300 csm

= 2300 × 2.32 = 5336 cfs

The SCS, as part of the design calculations, developed a Freeboard Inflow Hydrograph using SCS unit hydrograph technique. The peak inflow was calculated to be 6732 cfs. This will adopted as the Test Flood peak flow rate.

After storage routing through the reservoir, the peak outflow through the spillway was calculated by the SCS to be 4210 cfs. Storage routing is started at the 5-day drawdown level, elev. 1063.8.

From the Dam Rating Curve, this outflow of 4210 cfs will occur with a pool elevation of approximately 1076.3 MSL, 0.2 ~~feet~~ below the crest of the dam.

Drawdown Time

Sheet 31 of the SCS design calculations contains a drawdown time check.

Beginning at the level of the emergency spillway crest, elev. 1070.5, and assuming no inflow the 5-day drawdown level would be 1063.8 (6.7'), and the 90% drawdown occurs after 6.3 days.

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS